REGION V FIT STANDARD OPERATING PROCEDURES
FOR SAMPLING OF HAZARDOUS WASTES SITES
ADDENDUM H TO THE SI-QAPP
May 11, 1987

STANDARD OPERATING PROCEDURES
FOR
SAMPLING OF HAZARDOUS WASTE SITES

Ecology and Environment, Inc.
Field Investigation Team
Region V - Chicago

STANDARD OPERATING PROCEDURES
FOR
SAMPLING OF HAZARDOUS WASTE SITES

TABLE OF CONTENTS

TEXT

STANDARD OPERATING PROCEDURES

FOR

SAMPLING OF HAZARDOUS WASTE SITES

EXECUTIVE SUMMARY

I. INTRODUCTION

The Field Investigation Team (FIT) is organized to evaluate potential contaminant releases from hazardous waste sites for the United States Environmental Protection Agency (U.S. EPA). To accomplish this task, collection methods and field measurements involved in field investigations will be conducted in accordance with Standard Operating Procedures for Field Samplers, published by U.S. EPA, Region VIII, Environmental Services Division (ESD) in June, 1982, as well as this and other FIT Standard Operating Procedures (SOP). The sampling procedures and methodologies utilized by FIT in Region V will be compatible with sampling practices of ESD, and shipping will be per DOT and Sample Management Office Directives.

II. PURPOSE

The purpose of this document is to establish standard operating procedures for FIT field operations in Region V with respect to collection, handling and reporting of sample activities at designated hazardous waste sites. To accomplish this program, chapters describing sampling program development, sampling procedures, and handling of samples are provided.

This SOP serves as a reference for field samplers and provides guidance with respect to policies formulated by ESD and E&E in Region V.

III. SCOPE

A. The procedures outlined in this SOP are applicable to all FIT personnel participating in the collection of samples from Region V hazardous waste sites. The SOP is organized to address the various phases of sampling activity. The chapters are arranged in the chronological order of the site investigation process.

Chapter 1 - Purpose and Objectives of Sampling. This chapter specifies the objectives of sampling and defines sampling strategy.

Chapter 2 - Work Plan Development. A work plan is prepared before field work commences. The plan contains an outline of the proposed field activities including sampling. This chapter explains the organization of the work plan and provides an example of a work plan.

Chapter 3 - Field Safety Procedures, Organizations, and Operations. Information on field safety, team organizations, operational procedures, organizations of the field site and decontamination procedures employed in the safe execution of field operations is contained in FIT SOP III-1. Accordingly, this information, though essential to the safe field work, will not be repeated in this SOP. The reader is encouraged to refer to FIT SOP III-1, if detailed information in field safety is needed.

Chapter 4 - Recommended Field Equipment. A list of equipment is provided for field activities. The list covers equipment needs for: clothing of personnel, emergencies, safety, general sampling, special sampling, support facilities, and shipping.

Chapter 5 - Sampling Parameters, Containers and Preservation Techniques. This chapter lists considerations for selecting sampling parameters. It includes a description the container types, volumes, preservation techniques, and the maximum permissible holding times for samples.

Chapter 6 - Quality Assurance in Sampling. The acquisition of verifiable data is supported by a field program which includes:

calibration and continued maintenance of field equipment, proper techniques of collecting and preserving samples, methods for checking the precision and accuracy of analytical labs and documentation requirements. These basic elements of a quality assurance program are discussed in this chapter.

Chapter 7 - Field Measurements. Step by step procedures are provided for the measurement of the pH, conductivity and stream measurements. This section will be expanded as new field measuring equipment are brought on line.

Chapter 8 - Water Sampling. Techniques for sampling both surface and ground waters are described, and basic considerations for selecting sampling locations are included. Also included are descriptions of necessary equipment and techniques for obtaining samples. Sample collection techniques for obtaining samples of waste waters and potable water supplies are also discussed.

Chapter 9 - Soil and Sediment Sampling. Methods for collecting soil and sediment samples, selection of sampling locations, equipment, and collection techniques are presented in this chapter. Biased and random sampling techniques are discussed.

Chapter 10 - Hazardous Materials Sampling. The approach to sampling concentrated hazardous samples is addressed in this chapter. Various techniques for withdrawing samples are discussed, and explanations of special equipment are included. Techniques for the opening of closed containers are contained in the FIT SOP, "Container Opening and Sampling", February, 1982, and in FIT Guidance Manual, "Container Opening", March, 1982. Both of these documents are available in the FIT reference library.

Chapter 11 - Equipment Decontamination Procedures. Cleaning procedures for field equipment are discussed stepwise.

Chapter 12 - Sampling for Dioxin. Field procedures and documentation requirements for dioxin sites vary considerably from those for other types of hazardous waste sites. This chapter addresses some of these differences and provides references for in-depth guidance on dioxin sampling techniques.

Chapter 13 - Control of Contaminated Materials. Field investigations often result in the production or relocation of contaminated materials which must be properly managed to protect the public and environment and to meet legal requirements. This chapter deals with the proper management procedures for the containment and disposal of such material.

Chapter 14 - Sample Handling, Packaging and Shipping Procedures. After a sample is taken, it must be handled in a manner which will ensure that the sample will yield accurate analytical results. Also, proper safety procedures to protect the sample during shipping are provided. This chapter explains the necessary precautions, techniques, and legal requirements which must be used to ensure sample integrity.

Chapter 15 - Chain of Custody. Chain of custody procedures are described as they apply to sample transport and transfer during shipping.

Chapter 16 - Monitoring Well Installation/Groundwater, Studies. Guidelines for the installation of groundwater monitoring wells are described including drilling proposal, request for bids, and hydrologic report preparation.

Chapter 17 - Reference. This bibliography presents a list of references which serve as a supplement to this SOP.

B. As stated above, it is not within the scope of this SOP to review all of the safety procedures for entry into a hazardous waste site. Safety, however, is as critical during sample collections as during any other types of field operation. Accordingly, if the reader has questions regarding overall field safety procedures, reference should be made to FIT SOP's II-1 and III-1.

IV. COORDINATING INSTRUCTIONS

It is critical that all sampling activities be planned well in advance so that the necessary coordination between the different parties involved can be accomplished. Table IV lists the various steps involved with each sampling activity and the party responsible for coordination. To assure proper review and input all work plans should be submitted to ESD at least 21 days prior to commencement of field activities.

CHAPTER 1
PURPOSE AND OBJECTIVES OF SAMPLING

1.1 INTRODUCTION

Sampling is a useful tool for gauging the existence, type and extent of contamination of the environment by a hazardous substance. The data derived from the analysis of samples acquired during site inspections under CERCLA may become evidence for litigation. The objective of sampling is to obtain data which will assist investigative personnel in the identification of the hazardous substances present at a site and the occurrence and extent of hazardous substance migration.

Also, the data generated from analysis of samples often provides a crucial portion of the evidence used in subsequent litigation and may further be used in the development of appropriate remedial action alternatives. Therefore, the design of the sampling operation must ensure that the samples obtained will meet the goals of the investigation. Careful selection of sampling locations and methods also helps reduce the costs of labor and analytical support.

Figure A-1 demonstrates the various pathways by which contaminants may be dispersed. The potential for escape of contaminants by any of these means should be addressed in the sampling plan (Chapter 2).

1.2 FIT'S OBJECTIVES FOR SUPPORTING THE NATIONAL CONTINGENCY PLAN (NCP)

Under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the site evaluation phase extends from time of discovery through preliminary assessment and site inspection. FIT's role is to support the EPA during the site evaluation phase. The purpose of the site evaluation as stated in the NCP update (50 FR 5862, Feb. 12, 1985), is to determine the nature of potential threats occasioned by a release and to collect data for determining whether a release should be included on the National Priorities List (NPL). Preliminary assessments (PA's) consist of review of existing data and possibly include off-site reconnaissance. The goal of the PA is to:

- o determine whether the site can be eliminated from further consideration of releases which do not pose threats to public health and the environment

- o determine potential danger to persons living and working in the vicinity of such releases

- o establish priority for scheduling site inspections

Site inspections (SI's) consist of on-site visits, sampling and review of verifiable sampling data. The purpose of the SI is to:

- o determine whether a release poses no actual or potential threat to public health and the environment

- o determine whether there is an immediate potential danger to persons living or working in the vicinity of the release

- o collect data to determine whether a release should be placed on NPL

A site is required to pass one of two tests to become eligible for the NPL. The release must score above a threshold level on the Hazard Ranking System (HRS), or the release must be designated by a state as its highest priority release.

1.3 SAMPLING STRATEGIES FOR HAZARDOUS WASTE SITES

The general strategy for sampling at hazardous waste sites is to sample areas or containers most likely to give positive results of the presence of hazardous waste. In this manner, the contaminant source can be characterized. To demonstrate release of contaminants, samples are collected from the available routes of migration. The migration routes of concern are ground water, surface water and air. The evidence of contamination in these routes form the basis of the migration score in the HRS. Sampling may also be directed at evaluating potential for direct contact and fire and explosion routes.

FIT uses a biased approach to sampling to provide evidence of release. Background information collected during the PA can provide a basis for selecting areas to sample for source characterization. Lagoons, waste ponds, tailings, disposal trenches, etc., may be sampled directly to determine the identity of site contaminants. Off-site migration is measured by comparing contaminants' concentrations in downgradient samples with background samples. More description of sampling strategies and protocols is provided in the following chapters of this SOP.

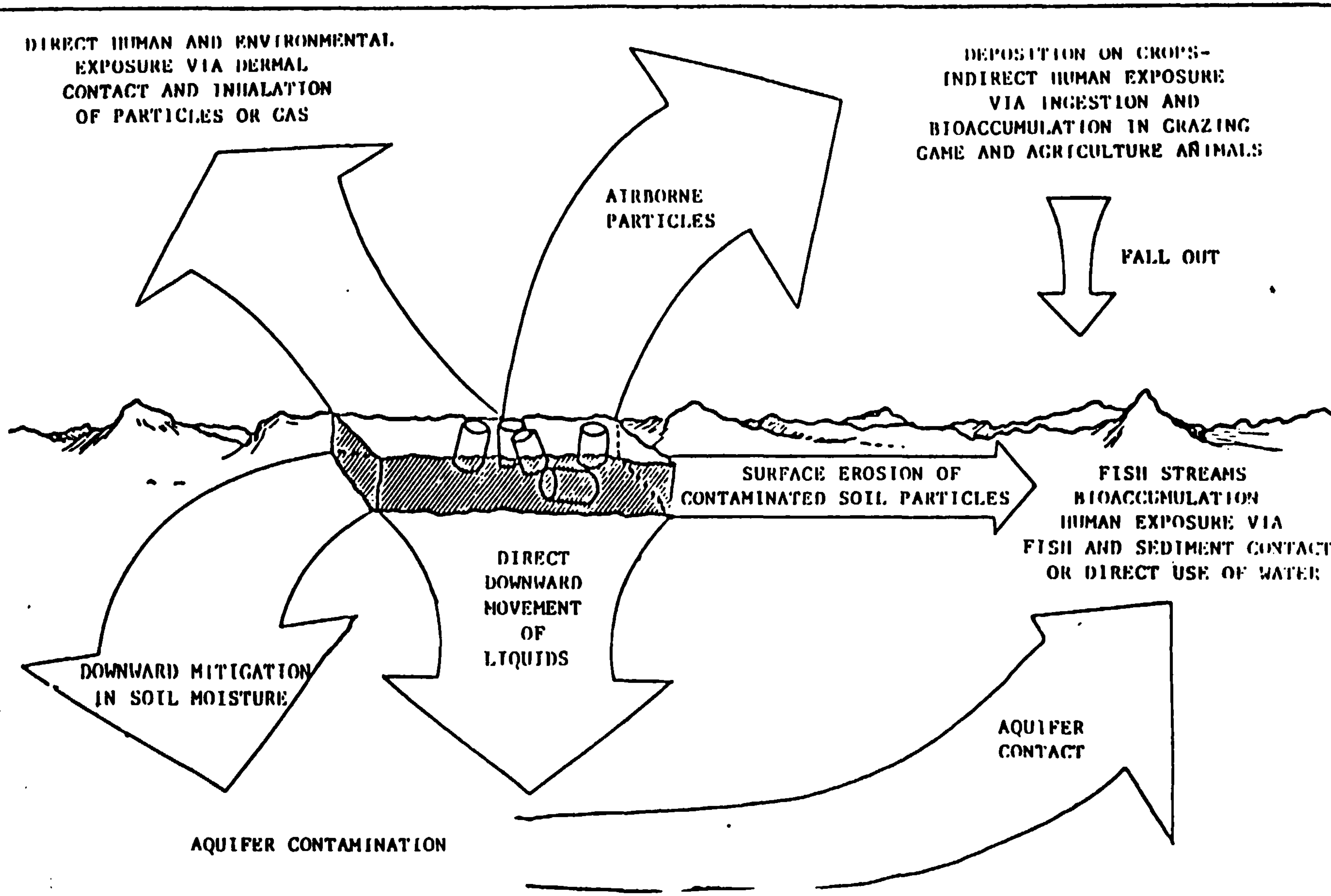


Figure A-1 DISPERSAL PATHWAYS

CHAPTER 2

WORK PLAN DEVELOPMENT

2.1 INTRODUCTION

A work plan describes the purpose and objectives of a site inspection and provides details of methodologies and safety procedures to be used. An example of a work plan for a hazardous waste site investigation is attached as Appendix 2-A to this chapter.

The work plan is a formal document that should be brief and concise. The work plan should always contain the following basic elements:

- A summary of background information for the site with emphasis on how this information can be used to identify investigation objectives.

- A statement of objectives and goals of the investigation. Typical investigation goals include confirmation of pollutant migration.

- Investigation methods required to characterize the site. Often this includes determining sample types, sampling locations, and sampling procedures. Other frequently used methods describe monitoring well installation, geophysical surveying, air sampling, waste inventory, etc.

- Personnel requirements. Only trained personnel familiar with safety procedures should be used in hazardous site work.

- Hazard Evaluation. Types of chemicals present and level of safety to be employed during the site activities.

- Any non-standard equipment which may be needed to complete the investigation.

As this list indicates, the work plan allows the FIT to schedule such resources as manpower, equipment and laboratory services efficiently in advance of a proposed investigation. The work plan is thus an essential tool in the investigation of sites containing hazardous substances.

2.2 ORGANIZATION OF THE WORK PLAN

The following is a description of the elements of a work plan:

1) General Information - Contains all relative information such as site name, TDD number, and objective of the site activities. Section also includes preliminary and projected HRS scores to indicate the effect of field activities on the HRS score of the site.

2) Site/Waste Characteristics - Site waste characteristics, including physical state and chemical charateristics, are provided to indicate potential problems in the areas of sample selection and safety. A facility description is also provided including a brief history to clarify waste disposal methods, unusual features, present status, and other aspects of the facility operation during the course of site operations.

3) Hazard Evaluation - Provides an indication of the level of protection to be employed at the site. Specific chemicals and their hazard evaluation sheets are provided to identify potential safety problems. The section provides modifications to the general safety procedures related to the level of protection.

4) Field Work Required - Types of field work are identified including geophysical work, monitoring well installation, and types of samples of to be taken. Sampling procedures are

detailed including special equipment and procedures.

5) Analytical Services Required - The RAS, SAS or CRL services required for samples to be collected are identified.

6) QAPP - Indicate whether a QAPP is required and attach the QAPP to the work plan, if necessary.

7) Work Team Size/Limitation. Team members are identified, and their disciplines and responsibilities are listed. Limitation on work activities during the field activities are indicated including times of day, heat stress or hypothermia, and OVA action levels.

TABLE IV-I

PROJECT OUTLINE

A. Work Plan Preparation

1. Site selection is performed by U.S. EPA.

2. RPO issues TDD to FIT RPM covering the Work Plan, Safety Plan, field activities and HRS preparation.

3. FIT State Coordinator select a Project Manager (PM).

4. FIT PM performs file search. PM prepares a work plan per the prescribed format.

5. The PM discusses the needs for laboratory analysis with the FIT Sample Coordinator.

6. State coordinator representative performs QA check on the draft Sample Plan.

7. The Safety Plan is prepared and signed off by the appropriate FIT personnel.

8. EPA ESD reviews the Work Plan, and a written approval is given with needed changes noted.

9. FIT PM gets lab assignments from Sample Coordinator and draws equipment from the Equipment Coordinator.

10. If well drilling is required, the assigned FIT geologist will manage the well drilling subcontract prior to the site sampler coming on the site.

11. The FIT PM makes all arrangements for site access, equipment, transportation, and all agency coordination.

12. FIT personnel performs the site inspection and ship samples to the appropriate CLP Labs and prepare all the necessary site documentation per prescribed protocols.

13. The appropriate sample coordination and routing information is given to the regional coordinator at the Sample Management Office.

14. After QA review by CRL, data are presented to the FIT PM for site interpretation and for completion of the final Site Inspection status report.

15. FIT prepares HRS package.

16. The final Site Inspection and the HRS report are quality checked prior to delivery to the EPA/PO; RPO; and REM-FIT coordinator.

17. The FIT PM prepares and AOC for RPM signature and closes the FIT TDD file.

ECOLOGY AND ENVIRONMENT, INC.

FIELD INVESTIGATION TEAM

SITE INSPECTION PLAN

A. GENERAL INFORMATION

SITE: ____________________ TDD NO.: __________

LOCATION: ____________________ U.S. EPA NO.: __________

____________________ SSID NO.: __________

____________________ WSTS NO.: __________

PLAN PREPARED BY: ____________________ DATE: __________

APPROVED BY: ____________________ DATE: __________

OBJECTIVE (including description of work to be performed): __________

DESIRED REPORT FORM: SI REPORT (2070-13) __________ HRS REPORT __________

OTHER (EXPLAIN) ____________________

PROPOSED DATE OF INVESTIGATION: ____________________

BACKGROUND REVIEW: Complete: ____ Preliminary: ____

HRS PRELIMINARY SCORE OF ROUTES: GW ______ SW ______ AIR ______
(NO FIELD WORK)

DIRECT CONTACT __________ FIRE AND EXPLOSION __________

TOTAL PRELIMINARY HRS SCORE VALUE (NO FIELD WORK) __________

PROJECTED HRS SCORE: GW ______ SW ______ AIR ______
(WITH FIELD WORK)

DIRECT CONTACT __________ FIRE AND EXPLOSION __________

TOTAL PROJECTED HRS SCORE __________

IF NO SAMPLING, EXPLAIN ON PAGE 3.

INSPECTION PRIORITY (BASED ON PROJECTED HRS SCORE): LOW:____ MEDIUM:____ HIGH: ____

B. SITE/WASTE CHARACTERISTICS

WASTE TYPE(S): Liquid ____ Solid ____ Sludge ____ Gas ____

CHARACTERISTIC(S): Corrosive ____ Ignitable ____ Radioactive ____ Volatile ____

Toxic ____ Reactive ____ Unknown ____ Other (Name) ____________

FACILITY DESCRIPTION: ______________________________

Principal Disposal Method (type and location): ______________________________

Unusual Features (dike integrity, power lines, terrain, etc.): ______________________________

Status: (active, inactive, unknown) ______________________________

History: (worker or non-worker injury; complaints from public; previous agency action): ______________________________

C. HAZARD EVALUATION

(Use Hazard Evaluation of Chemicals sheets for specific or representative chemicals present.): ______________________________

LEVEL OF PROTECTION: A ____ B ____ C ____ D ____

MODIFICATIONS: ____

____

____

____

____

____

SITE SAFETY PLAN ON FILE AT E & E: YES ____ NO ____

____

D. FIELD WORK REQUIRED

PERIMETER ESTABLISHMENT: MAP/SKETCH ATTACHED? YES ____ NO ____

Perimeter Identified? YES ____ NO ____

Zone(s) of Contamination Identified? YES ____ NO ____

Geophysical Work: YES ____ NO ____

Type: Magnetometry ____ Seismic Refraction ____ GPR ____ Resistivity ____ Other____

Comments: ____

____

Drilling: YES ____ NO ____

Well Location Identified: YES ____ NO ____

Drill Plan/Well Installation Plan Attached: YES ____ NO ____

Sampling Required: YES ____ NO ____

Type: GW ____ SW ____ Air ____ Soil ____ Waste ____ Other ____

Sampling Locations Identified: YES ____ NO ____

SUMMARY OF SAMPLING PROCEDURES: (Special Equipment, Facilities, or Procedures)

____

____

____

____

____

____

____

____

____

E. ANALYTICAL SERVICES REQUIRED

RAS ____ SAS ____ CRL ____

F. QAPP

REQUIRED: YES ____ NO ____

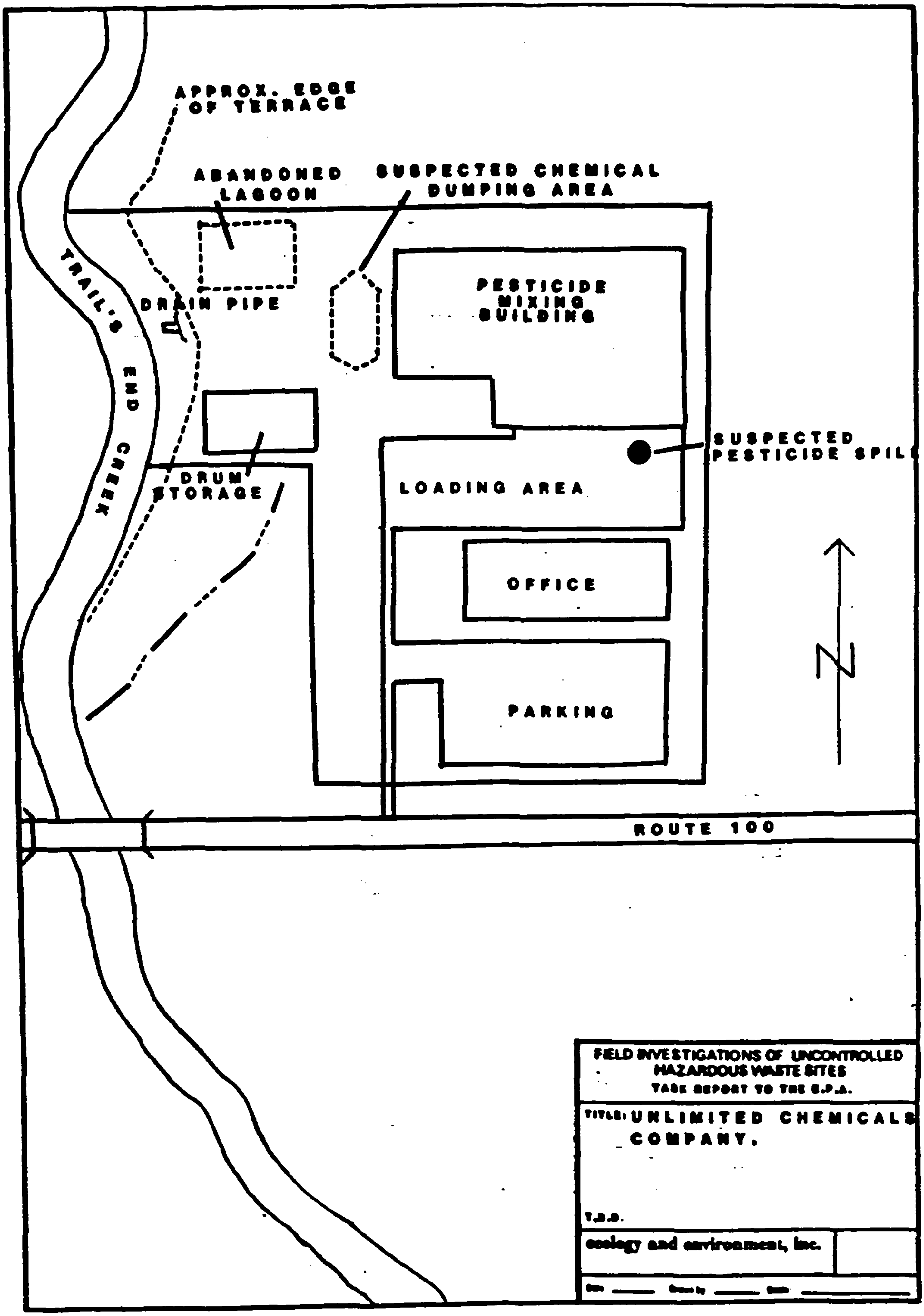
IF NO, EXPLAIN: ____________________

G. SI WORK TEAM SIZE/LIMITATION

TEAM MEMBER	DISCIPLINE	RESPONSIBILITY

WORK LIMITATIONS (Time of day, etc.): ____________________

COMMENTS: ____________________


APPROX. EDGE OF TERRACE
ABANDONED LAGOON
SUSPECTED CHEMICAL DUMPING AREA
PESTICIDE MIXING BUILDING
DRAIN PIPE
TRAIL'S END CREEK
DRUM STORAGE
LOADING AREA
SUSPECTED PESTICIDE SPILL
OFFICE
PARKING
N
ROUTE 100
FIELD INVESTIGATIONS OF UNCONTROLLED HAZARDOUS WASTE SITES
TASK REPORT TO THE E.P.A.
TITLE: UNLIMITED CHEMICALS COMPANY.
T.D.D.
ecology and environment, inc.

CHAPTER 3

FIELD SAFETY PROCEDURES, ORGANIZATION AND OPERATIONS

The collection of concentrated and other high hazard samples requires special precautions to be taken. The procedures for field operations, safety and organization at the site are contained in FIT SOP III-1, "On-Site Inspection and Investigations". It must be emphasized that use of the elaborate safety and operational procedures stated in that SOP are only used during the collection of medium or high hazard samples. Generally, such elaborate procedures are not necessary during the collection of routine off-site and on-site environmental samples.

No sampling study will be conducted without development of a site safety plan. The safety plan generated for a site depends on both the hazards known or suspected on the site and the specific planned tasks for the site investigation. The essential elements of the safety plan are:

- description of site characteristics,

- statement on hazard evaluation,

- work plan information, including site entry personnel, site entry procedures, command post location, required protective equipment and decontamination procedures,

- specific hazard emergency data,

- a contingency plan that provides necessary resources for handling emergencies on-site and includes a site map, directions to the site, emergency communication procedures, contacts (telephone numbers) and directions to a hospital and/or other emergency facilities, and

- An On-Site Safety Meeting Form and Data Log to be signed by all personnel doing on-site work (including subcontractors).

An example of a site safety plan is attached as Appendix 3-A. The site safety plan is prepared by the Site Project Manager or his or her designate and given to the Region V Safety Coordinator for review and/or revision. All safety plans must be approved by the Region V Safety Coordinator or Regional Project Manager prior to fieldwork.

APPENDIX 3-A

EXAMPLE FORMAT OF A REGION V SITE SAFETY PLAN

ECOLOGY AND ENVIRONMENT, INC.

FIELD INVESTIGATION TEAM

SITE SAFETY PLAN

A. GENERAL INFORMATION

SITE: ______________________ TDD NO: ____________

WSTS NO: ____________

LOCATION: ______________________

PLAN PREPARED BY: ______________________ DATE: ____________

APPROVED BY: ______________________ DATE: ____________

OBJECTIVE (including description of work to be performed): ____________

____

____

____

____

____

____

PROPOSED DATE OF INVESTIGATION: ______________________

BACKGROUND REVIEW: Complete: ________ Preliminary: ________

DOCUMENTATION SUMMARY: OVERALL HAZARD: Serious: ______ Moderate: ______

Low: ______ Unknown: ______

B. SITE/WASTE CHARACTERISTICS

WASTE TYPE(S): Liquid ______ Solid ___ Sludge ___ Gas _____

CHARACTERISTIC(S): Corrosive ____ Ignitable ______ Radioactive _____

Volatile ____ Toxic _____ Reactive ___ Unknown ____ Other (Name) ___

FACILITY DESCRIPTION: ______________________

____

____

Principal Disposal Method (type and location): ______________________

____

Unusual Features (dike intergrity, power lines, terrain, etc.): ____________

____

Status: (active, inactive, unknown) ______________________

____

History: (Worker or non-worker injury; complaints from public; previous agency action): ____

C. HAZARD EVALUATION

(Use Hazard Evaluation of Chemicals sheets for specific or representative chemicals present.): ____

D. SITE SAFETY WORK PLAN

PERIMETER ESTABLISHMENT: Map/Sketch Attached ____ Site Secured? ____

Perimeter Identified? ____ Zone(s) of Contamination Identified? ____

PERSONAL PROTECTION

Level of Protection: A ____ B ____ C ____ D ____

Modifications: ____

Surveillance Equipment and Materials: ____

DECONTAMINATION PROCEDURES: ____________________

Special Equipment, Facilities, or Procedures: ____________________

SITE ENTRY PROCEDURES: ____________________

Team Member	Responsibility

WORK LIMITATIONS (Time of day, etc.): ____________________

INVESTIGATION-DERIVED MATERIAL DISPOSAL: ____________________

E. EMERGENCY INFORMATION*

LOCAL RESOURCES

Ambulance ______________________________
Hospital Emergency Room ______________________________
Poison Control Center ______________________________
Police ______________________________
Fire Department ______________________________
Airport ______________________________
Explosives Unit ______________________________
EPA Contact ______________________________

SITE RESOURCES

Water Supply ______________________________
Telephone ______________________________
Radio ______________________________
Other ______________________________

EMERGENCY CONTACTS

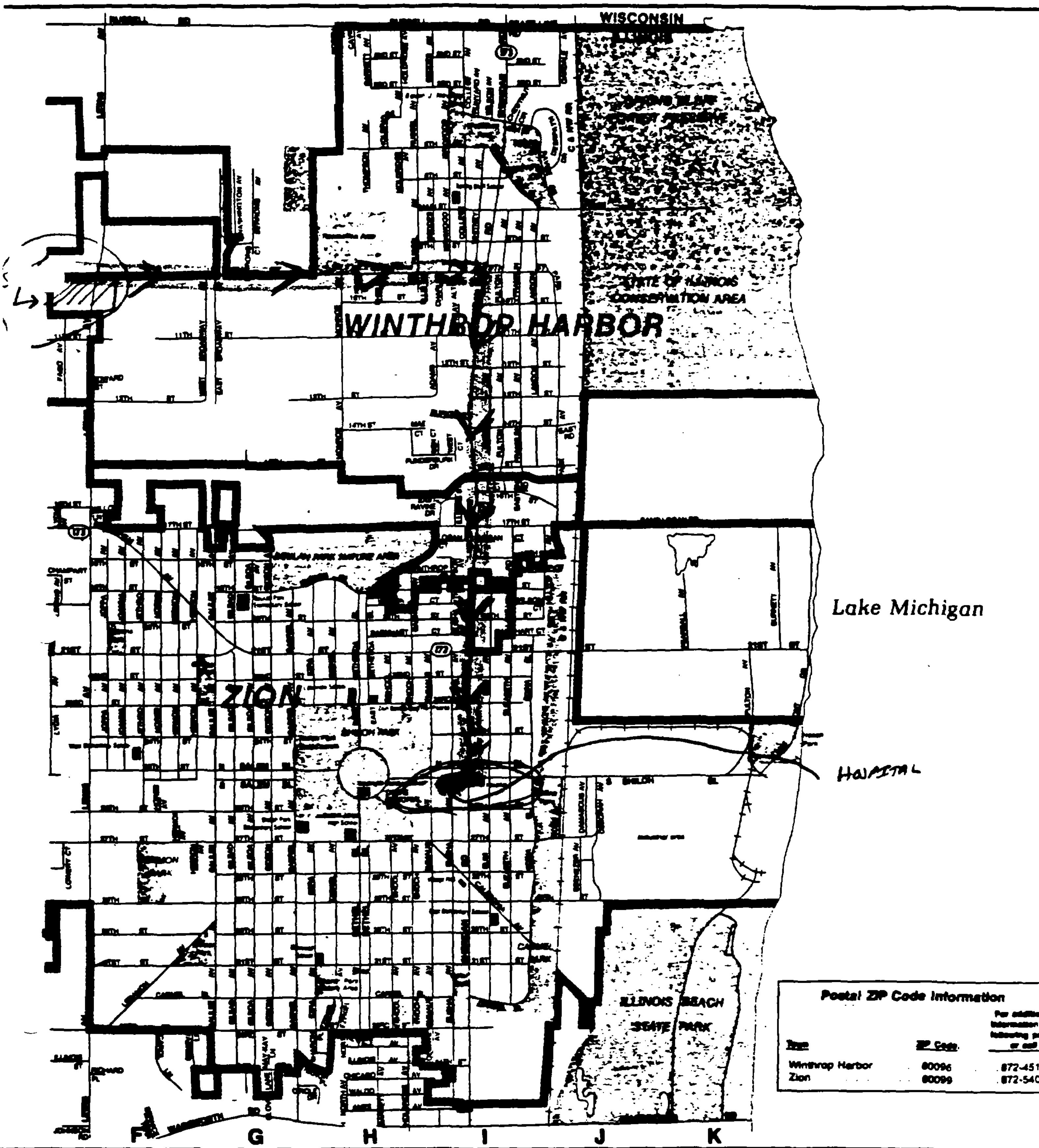
1. Dr. Raymond Harbison (University of Arkansas) .... (501) 661-5766 or 661-5767
   MED-TOX .... (501) 370-8263 (24 hours)
2. Regional Safety Coordinator - Paul Moss .... (312) 541-6635 (24 hours)
3. FIT Leader - Joseph Petrilli .... (312) 561-7639
4. FIT Office .... (312) 663-9415
5. E & E 24 Hour Call Line .... (716) 631-9530 (24 Hours; Call Forwarding)
6. Regional Health Maintenance Program Contact .... PMI - (312) 832-8820
   8:00 a.m. - 5:00 p.m.
7. Paul Jonmaire.. (716) 632-4491 (office)
   Corporate Safety Director
8. Ecology and Environment, Inc. NPMO .... (703) 522-6065

F. EMERGENCY ROUTES

(Give road or other directions; attach map)

Hospital: ______________________________
____
____

Example of Hospital Route
From Site:



ecology and environment, inc.

HAZARD EVALUATION OF CHEMICALS

Chemical Name ______________________ Date ______________________

DOT Name ______________________ TDD Number ______________________

CAS Number ______________________

References Consulted (circle):

NIOSH/OSHA Pocket Guide   Verschueren   Merck Index   Hazardline   Chris (Vol. II)

Toxic and Hazardous Safety Manual   ACGIH   Other: ______________________

Chemical Properties: (Synonyms: ______________________)

Chemical Formula ______________ Molecular Weight ______________

Physical State __________ Solubility (H_2O) __________ Boiling Point __________

Flash Point __________ Vapor Pressure/Density __________ Freezing Point __________

Specific Gravity __________ Odor/Odor Threshold __________ Flammable Limits __________

Incompatabilities ______________________

Biological Properties:

TLV-TWA ______________ PEL ______________

IDLH __________ Human __________ Aquatic __________ Rat/Mouse __________

Route of Exposure ______________________

Carcinogen __________ Teratogen __________ Mutagen __________

Handling Recommendations: (Personal protective measures)

____

____

Disposal/Waste Treatment:

____

____

Health Hazards and First Aid:

____

____

Symptoms: Acute: ______________________

____

Chronic: ______________________

____

375103
(12/83,DLD)

SITE DOSIMETER LOG

TDD# ____________________ SITE NAME ____________________

SITE SAFETY OFFICER ____________________ WEEK OF ____________________

NAME AND DOSIM. #	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY

To the nearest half-hour, record time spent downrange as "S" (e.g., S: 2.5 hrs), time spent in active PDS operation as "P", and any time spent downrange in rescue activity as "R".

ECOLOGY & ENVIRONMENT, INC.
REGION V EQUIPMENT LIST

Team Leader: ____________________
TDD Number: ____________________
Date of Departure: ____________________
Date of Expected Return: ____________________

A. Safety Instruments

		(Please Circle)
____	Drager Pump	A B C D E F
____	MSA 2A Explosimeter	A B C D E F G
____	MSA 260 Combustible Gas/O_2 Alarm	A
____	HNU 101	A B C D E F
____	Lamp Type: 10.2 or 11.7	
____	MSA 245 Oxygen Indicator	A B C D E F
____	Organic Vapor Analyses (OVA)	A B C
____	Radiation - Mini	A B C D E F G
____	Radiation - Survey Meter	A B C
____	Rad - Tad	A B
____	Radiation - Thyac III/Probe	A B C
____	Dust Monitor - MDA System	A
____	Monitox Hydrogen Cyanide Detector	A

B. First Aid Equipment

____	First Aid Kit	1 2 3 4 5 6 7 8
____	Eyewash Bottle	
____	Oxygen Inhalator	A B C
____	Blood Pressure Monitor	
____	Radiation TLD Badges	
____	Safety Glasses	
____	Lifevests	
____	Hard Hats	
____	Face Shields	
____	Ear Plugs	

C. Respiratory Equipment

____	Ultratwin Respirator	Qty: ____
____	Racal Air-powered Respirator	Qty: ____
____	MSA Air-powered Respirator	Qty: ____
____	Robert Shaw Escape Mask	Qty: ____
____	MSA SCBA	Qty: ____
____	Extra Air Cylinders	Qty: ____

P.D. Moss (Rev. 4/85)

D. Respirator Cartridges

GMC-H	Qty:	_____
GM-P	Qty:	_____
HEPA	Qty:	_____
Other __________	Qty:	_____

E. Misc. Instrumentation

_______	Airdrive Pump (Geofilter)	A
_______	Canon AEL Camera	A B C
_______	Conductivity Meter	A B C D
_______	Level/Tripod and Rod	A B C
_______	Masterflex Pump and Filter	A B
_______	Metal Detector	A B C
_______	pH Meter	A B C D
_______	Polarid One-step Camera	A B C D
_______	Resistivity Meter	A
_______	Robair Pump System	A
_______	Water-level Indicator	A B C
_______	Magnetometer	A B
_______	Air Sampling Pump Kits	A B C D E
_______	Buck Calibrator	A
_______	HNU 301 System	A
_______	Thermal Desorber	A B
_______	Meteorological (Weather) Station	A
_______	Binoculars	

F. Vehicles

_______	Step Van	A B C
_______	Cargo Van	A
_______	Suburban	A B

G. Protective Clothing

1) Outerware

Splash Aprons	Qty: _____	Butyl Acid Suits	Qty: _____
Saranax	Qty: _____	Cold-weather Suits	Qty: _____
Tyvek	Qty: _____	Other __________	Qty: _____
Coveralls	Qty: _____	Fully-encapsulated Suit	Qty: _____

2) Gloves

Latex Disposable	Qty: ____	Viton		Qty: ____	
Butyl Rubber	Qty: ____	Winter Drilling		Qty: ____	
Nitrile	Qty: ____	Other ________		Qty: ____	
Neoprene	Qty: ____				

3) Boots

Neoprene Qty: ____
Latex Disposable Qty: ____
Steel-toe Qty: ____
Cold-weather
i.e., sorrel Qty: ____
Other ________ Qty: ____

H. Sample Bottles and Equipment

80 oz. Qty: ____
40 ml. Qty: ____
1 liter Qty: ____
120 ml. Qty: ____
8 oz. Qty: ____
32 oz. Qty: ____
Metal cans,
clips, and lids Qty: ____
Bailers Qty: ____

I. Preservatives

$NaOH$ ________
HN_3 ________
H_2SO_4 ________
Other ________

J. Drager Tubes

Hydrogen Cyanide Qty: ____
Sulfuric Acid Qty: ____
Natural Gas (Methane) Qty: ____
Arsenic Trioxide Qty: ____
Ammonia Qty: ____
Vinyl-chloride Qty: ____
Other ________ Qty: ____

K. Decon Supplies

Wash Tubs	Qty:	______
Buckets	Qty:	______
Scrub Brushes	Qty:	______
Pressurized Sprayer	Qty:	______
Trash Bags	Qty:	______
Tarps	Qty:	______
Duct Tape	Qty:	______
Solvent	Type:	______
Detergent	Type:	______
MSA Sanitizing Solution	Qty:	______

P.D. Moss (Rev. 4/85)

PM:4X

*Form to be used for confined space, when necessary.

*ecology and environment, inc.

INSPECTIONS AND TESTS FOR ENTRY INTO CONFINED SPACES

Date ______
Page __ of __

Job Name: ______________________ Job No.: ______________________

Job Location: ______________________ Tank or Vessel No./Name: ______________________

______________________ ______________________

Nature of Material: ______________________

Description of Work Planned: ______________________

TEST RESULTS

	Time	Explos-imeter	Oxygen Meter (% Oxygen)	OVA Meter	HNU Indi-cator	Draeger Tubes (Type)	Draeger Tubes (ppm)	Personal Pump Sampling/ Other Indicators			Initi
(Entry)											
(Exit)											

CHECK LIST

	Initials: Yes	Initials: Does Not Apply
Work plan approved and attached		
Site safety plan, including chemical hazards of tank contents, approved and attached		
Heat/cold stress monitoring to be carried out		
Pre-entry atmospheric monitoring and characterization, as well as continuous monitoring during work		
Contingency plans prepared (communications, rescue)		
All product lines leading to and from confined space have been disconnected		
Electrical service disconnected or locked out		
All grounding and bonding wire in place		
All ignition sources have been isolated		
The complete respiratory protection system has been checked and is in proper condition		
All safety harnesses and life lines checked and in proper condition		
Required protective clothing being used		
Employees have been trained in the use, care, and limitations of their protective equipment		
Outside safety watch trained in emergency procedures and resuscitation		
Vessel contains leaded product		
All emergency systems such as fire extinguishers, alarms, etc., ready for use		
Special warning/caution signs posted		
Ventilation equipment in use		
Employees have currently valid medical examination		

PERSONNEL PROTECTION EQUIPMENT

Personnel Protection Level

☐ A. (SCBA, Encapsulated Suit)
Modifications ______________________

☐ B. (SCBA, Dermal)
Modifications ______________________

☐ C. (APR, Dermal)
Modifications ______________________

☐ D. (No Protection)
Modifications ______________________

Eyes

☐ Face Shield

☐ Safety Glasses

Extremities

☐ Hard Hat

☐ Gloves Type ______________________

☐ Boots

☐ Hoods

☐ Booties

Body

☐ Encapsulated Suit

☐ Acid Splash Suit

☐ Disposable Tyvek Coating ______________________

☐ Apron

☐ Other ______________________

Respirators

☐ SCBA

☐ Hose Line in Use

☐ Emergency Escape Device

☐ Cartridge Respirator, Cartridge Type ________

Other

☐ Hearing Protection

☐ Parachute Harness and Lifeline (Top Entry)

☐ Chest Harness and Lifeline (Side Entry)

☐ Other Protective Equipment in Use (List)
____

Special Instructions: ______________________

Completed by Site Safety Officer: ______________ ______________ ______________

Name Printed | Signature | Date

____

Project Manager/Team Leader

ECOLOGY AND ENVIRONMENT, INC.
FIELD INVESTIGATION TEAM
ON-SITE SAFETY MEETING

Project ______________________________

Date ____________ Time ____________ Job No. ____________

Address ______________________________

Specific Location ______________________________

Type of Work ______________________________

____

____

SAFETY TOPICS PRESENTED

Protective Clothing/Equipment ______________________________

____

Chemical Hazards ______________________________

____

Physical Hazards ______________________________

____

Emergency Procedures ______________________________

____

Hospital/Clinic ____________________ Phone ____________

Special Equipment ______________________________

____

Other ______________________________

____

ECOLOGY AND ENVIRONMENT, INC.
FIELD INVESTIGATION TEAM
ON-SITE SAFETY MEETING

ATTENDEES

Name (Printed)	Signature

Meeting Conducted By:

Site Safety Officer:

Team Leader:

ON-SITE SAFETY LOG

ECOLOGY AND ENVIRONMENT, INC.
CHICAGO

A. ON-SITE MONITORING

	EQUIPMENT USED	BACKGROUND READING IN BREATHING ZONE	CALIBRATED AT	ON-SITE READING IN BREATHING ZONE
1.				
2.				
3.				
4.				
5.				

B. PROTECTIVE CLOTHING WORN: ______________________

____

____

____

C. SITE NAME: ______________________ PROJECT NUMBER: ______________________

DATE: ______________________

WEATHER CONDITIONS: ______________________

NAMES OF ATTENDEES AT SITE: ______________________

____

D. COMMENTS ON MONITORING OR PROTECTIVE CLOTHING ______________________

____

____

	NAME	SIGNATURE
TEAM LEADER:		
SITE SAFETY OFFICER:		

(P.D. Moss, 1/85)

CHAPTER 4
RECOMMENDED FIELD EQUIPMENT

4.1 INTRODUCTION

The following is a suggested inventory of equipment which may be used during field operations at hazardous waste sites. Although no list can include every necessary item, the lists in this chapter are basic for most non-specialized investigations. The following categories are covered in the equipment list:

personal clothing and equipment,
emergency equipment,
respiratory protection and safety equipment,
tools and vehicular equipment,
general environmental evaluation equipment,
special environmental evaluation equipment
support equipment and office supplies, and
shipping supplies and labels.

4.2 PERSONNEL CLOTHING AND EQUIPMENT

Items of personnel clothing and equipment listed below are issue to each member of the field investigation team. Team members are responsible for security and maintenance of their personal equipment.

Work boots with steel toe and shank
Cotton Underwear (summer and winter)
Coveralls (Chemical-resistant, cotton)
Duffle Bag
Ear Plugs
Glasses (safety and insert prescription)
Hard Hat with Face Shield
Jacket or Parka
Rain Suit

Socks (cotton)
Winter Clothing

4.3 EMERGENCY EQUIPMENT

Emergency Equipment is available in the field on a team basis in the event that it is needed.

- Emergency Oxygen Administrator
- Fire Extinguisher
- First-Aid Kit
- Potable Eye/Face Wash Unit
- Stretcher
- Wool Blankets
- Wood Splints

4.4 RESPIRATORY PROTECTION AND SAFETY EQUIPMENT

Items of respiratory protection and safety equipment are maintained in a controlled temperature environment and are issued as needed for on-site work. This equipment is critical to the welfare of team members working on hazardous substance sites and must be carefully maintained and inspected regularly.

- Air Escape Mask
- Air-Purifying Respirator (with cartridges)
- Air Tank Refill System with type A cylinders of Grade "D" or better breathable air
- Butyl Rubber Apron
- Butyl Rubber Booties
- Butyl Rubber, Neoprene, Nitrile or Viton Gloves
- Coveralls (disposable)
- Fully Encapsulated Suit (butyl rubber)
- Life Vests
- Powered Air Purifying Respirator
- Self-Contained Breathing Apparatus (with extra tanks)
- Surgeon's Gloves, Cotton Gloves

4.5 TOOLS AND VEHICULAR EQUIPMENT

The following items are included for their general utility in field situations.

Booster Cables (12')
Bow Saw (30")
Broom
Curved-Back Wire Brush
Drum filled with tap water
Duckbill Snips (12")
Electrical Tape
Grounding Rod
Hacksaw (with blades)
Hammer (ballpeen, carpenter's, machinist's, and 4-lb. sledge)
Hatchet (13")
Hose (garden 50' or more with nozzle)
Hydraulic Jack
Machete
Measuring Tape
Oil Spout, extra oil filter, oil
Paint (fluorescent)
Pick (25" non-sparking)
Pliers (8" diagonal cutting, 10" forged slip joint, 8" lineman's, 8" long nose, and 8" slipjoint)
Pocket Knife
Pry Bar
Radio Headsets (Unicom)
Reflectors (safety warning)
Rubber Mallet
Safety Flares
Screwdrivers (5 slotted and 4 Phillips)
Shovel (D-handle, round point, nonsparking)
Tire Chains
Tire Pressure Gauge
Tool Box

Tow Chain (14' heavy duty)
Trouble Hook w/Rope
Truck Jack
Wooden Mallet
Wrecking Bar (non-sparking)
Wrenches, assorted sizes

4.6 GENERAL ENVIRONMENTAL EVALUATION EQUIPMENT

The items listed below have uses related to the acquisition of data and samples for the basic characterization of a site.

4.6.1 Soil and Sediment Sampling Equipment

Aluminum Foil
Bucket Auger (3" w/handle)
Camera 35mm
Chain-of-Custody Seals
Dredge
Glass Jars (8 oz, wide mouth w/Teflon lined caps)
Labels
Labscoops (w/handles)
Mobile Soil Drill
Plastic sheets/tarps
Posthole Digger
Split Spoon Sampler (2" x 1.5" diameter, 24" x 18" length)
Scoop
Shovel
Spatula (stainless steel 8")
Tape (Teflon)
Vials (VOA 120 ml w/TEflon lined Caps)
Wire Tags
Wooden Spoons

4.6.2 Water Sampling Equipment

Air Lift Pumps
Automatic Dispenser (pipettor)
Bailers (Stainless Steel)
Bucket Auger (3" s/handle)
Buffer Solutions (pH 4, pH 7 and pH 10)
Chain-of-Custody Seals
Container Brush
Conductivity Meter and calibration solutions
Containers (with screw caps lined with Teflon)
Dissolved Oxygen Indicator (w/probe for field use)
Distilled Water
Electrical Tape
Ground water flow meter
Grease pencils
Hip Boots
Nansen-Style Bottles (water sampling with case)
Oil absorbing pillows
Pitcher Pump
pH Meter and pH Hydrion paper - wide range
Plastic Beaker (1000 ml)
Polyethylene Bags (8"x12", 10"x16", and 12"x20")
Pressure Filtering Apparatus
.45 micron filters and prefilter
Pulley
Rope (nylon, 3/16" and 1/4")
Safety goggles
Sampling Pump (w/add-on head)
Stainless Steel Safety Lab Can
Submersible Pump (2" and 4")
Thermometer (armored 305 mm)
Thermometer (yellow, 20-1100)
Tubing (silicone 0.433" OD)
Tubing (teflon, 1/4")
Turbine Pump and Generator

Wash Bottles (500 ml)
Wash Bailer (teflon or stainless steel)
Water Level Indicator (electric or tape)
Well Pump (peristaltic)
Whirlpak Bags
Wire Tags

4.6.3 <u>Air Sampling Equipment</u>

Air Sampler (Hi-vol)
Barometer Pressure Indicator
Adsorpton Tubes
Colorimetric Tubes (Draeger tubes)
Explosimeter
HNu Vapor Analyzer
OVA
Oxygen Meter
Personal Air Sampling Pumps
Temperature Indicator
Thermal desorber
Wind Speed and Direction Indicator and Chart recorder

4.6.4 <u>Chemicals</u>

Acetone (reagent grade)
Ascorbic Acid
Cupric Sulfate (anhydrous, reagent grade)
HTH, Calcium Hypochlorite
Hydrochloric acid (reagent grade)
Nitric Acid (reagent grade)
Sodium Carbonate
Sodium Dithionate
Sodium Hydroxide
Sulfuric Acid (reagent grade)
Zinc Acetate (reagent grade)
Deionized Water

Metals free water
Organics free water

4.7 SPECIAL ENVIRONMENTAL EVALUATION EQUIPMENT

The items listed below have uses related to the acquisition of data samples which will be applied toward characterization of especially hazardous sites.

4.7.1 Ambient Site Characterization Equipment

Camera (35 mm)
Colorimetric Tubes (length-of-stain)
Conductivity Meter (EM 31, EM 34)
Draeger Gas Detector
Explosimeter (w/probe and calibrating test kit)
Magnetometer (Geometrics G-856)
Maps
Metal Detector
Oxygen Indicator
Photoionization Detector (portable)
Portable Gas Chromatograph (OVA, Photovac, HNU 301)
Radiation Dosimeter (Eberline badges, TLD)
Radiation Meter (Thyac III, Victoreen)
Radiation Monitor with audible alarm (Rad-mini)
Rangefinder
Resistivity Meter
Single Channel Seismic Unit (Bison 2350B and 1570C)
Surveying Equipment-Brunton Compass and 100'tape
Video Camera

4.7.2 Hazardous Material Sampling Equipment

Brass Spoon (non-sparking)
Drum Opener, remote/universal bung remover
Drum Sealer

Flask, Erlenmeyer Filtering (250 ml with #6 one-hole stopper)
Flask, Erlenmeyer Filtering (500 ml with solid stopper)
Jars (8 oz, wide-mouth w/Teflon lined caps)
pH Indicating Paper (wide and narrow range)
Plastic Bags (assorted sizes with elastic closures; self-sealing not recommended)
Plastic Sheeting
Silicone Rubber Cement
Stoppers (solid rubber, assorted sizes to fit tubing)
Stoppers (2-hole, fixed with short lengths of glass tubing to fit neck of sample bottles)
String (chemically resistant or fine steel wire)
Tongs (wooden, disposable)
Tubing (glass, 4-ft. lengths, 17 mm ID w/#1 1-hole stopper)
Tubing (polyethylene, 4 ft. lengths; 6 mm to 20 mm ID)
Tubing (pyrex, 15 mm and 22 mm)
Tubing (teflon, chemically resistant, 5/16" ID)
Tubing (Tygon, assorted lengths, 5/16" ID)
Valve (teflon 3-way)
Vials (VOA 40 ml, with septum caps and Teflon-backed septa)
Wooden Doweling (assorted lengths)

4.8 SUPPORT EQUIPMENT AND OFFICE SUPPLIES

The following list contains equipment and supplies necessary for setting up and operating field command posts and decontamination areas.

Bags (trash, plastic)
Binoculars (wide angle 7 x 35)
Bucket (11 qt. plastic)
Bucket (stainless steel, 15.5 qt)
Brown Wrapping Paper
Card Table
CB Radios (Motorola High Frequency)
Cellophane Tape

Chaining Pin Set
Chairs (card table)
Clipboards
Clips (paper and alligator)
Composition Book (numbered pages)
Dairy Brushes
Desk Stereoscope
Detergent (Alconox)
Duckback Book (waterproof)
Electrician's Tape
Engineer's Tape (12 ft.)
Extension Cord
Fiberglass Tape (lock type, open reel, 100')
Fiberglass Tape (open reel, 200')
Filament Tape (1/2 in. and 1" wide)
Flagging Tape
Garbage Can (w/top)
Ground Plastic Sheets
Ground Tarp
Hand Calculator
Hand Lens
Lantern (rechargeable)
Level (hand, 2X)
Magnetic Hangers
Masking Tape (2" wide)
Note Pads
Nylon Twine
Overhead Tarp (w/rope and stakes)
Pens, Pencils and Markers
Portable High Pressure Water Cleaners
Power Alternator
Recorder (microcassette)
Redwood Plugs (various sizes)
Rope and stakes (for cordoning off area)
Rubber Bands
Scrub Brushes

Shower Curtain
Signs ("caution", "restricted area")
Sprayer (garden, 4 gal.)
Stakes, wooden
Stapler (heavy duty)
Tissues
Trisodium Phosphate for cleaning after oily contamination
Transcriber (microcassette)
Wash Tubs
Water Jugs (collapsible 5-gal)
Wheelbarrow
Wood Benches

4.9 SHIPPING SUPPLIES AND LABELS

Listed below are items used in the shipment of samples and equipment. Such shipments are carefully regulated by the U.S. Department of Transportation and must be prepared in accordance with DOT requirements to avoid legal penalties. U.S. Environmental Agency sample chain-of-custody provisions must also be kept in mind.

The reference for DOT specifications for shipping is the 49 CFR, particularly 172.101. The Bureau of Explosives Tariff No. BOE-6000 may also be consulted.

Address labels
Air Bills (Hazardous and non-hazardous)
Chain of Custody forms
Coolers (48 qt. or 20 gallon)
Electrical Tape
Evidence Tape
Fiberglass Tape (1" and 2")
Foam Rubber
Garbage Bags
Ice
Knife

Lab Services Request Form

Labels -

- Corrosive
- Danger - Peligro
- Dangerous When Wet
- Empty
- Explosive A, B and C
- Flammable Gas
- Flammable Liquid
- Flammable Liquid N.O.S.
- Flammable Solid
- Flammable Solid N.O.S.
- Fragile
- Hydrogen
- Irritant
- Limited Quantity
- Limited Quantity (73° or higher)
- Non-Flammable Gas
- Organic Peroxide
- ORMA Dry Ice
- Oxidizer
- Poison
- Poison A
- Poison B
- Poison Gas
- Poison Liquid N.O.S.
- Radioactivity I, II and III
- This End Up

Masking Tape (2")

Marker

Metal Paint Can (half gallon with lid and sealing clips)

Official Sample Seal (USEPA) (EPA Form 7500-2, R7-75)

Rubber Stopper (size 000, solid; for cooler drain)

Shipper's Certification for Restricted Articles

Traffic Report forms

Vermiculite

CHAPTER 5
SAMPLE REQUIREMENTS, CONTAINERS AND PRESERVATION TECHNIQUES

5.1 INTRODUCTION

Samples collected during investigation of hazardous waste sites are contained and preserved according to their matrix, the type of analysis to be performed and the anticipated concentrations. Detailed information about handling specific types of samples is provided in Chapters 8, 9, 10 and 11. The function of this chapter is to inform samplers about the recommended container required for each sample type, amount of sample required for the contract laboratory program, proper procedures for preservation, and the maximum allowable holding time before analyses of samples.

Preservatives are added to retard biological action and prevent loss of aqueous inorganic species (as ions and complexes). Preservation methods are generally limited to chemical addition, pH control and refrigeration.

5.2 SAMPLE MATRICES

The matrices sampled during a site investigation will depend on site specific conditions. The primary objectives of sampling are to detect and characterize contaminants and to identify movement of contaminants by means of examining different migration pathways. A variety of types of matrices could be encountered at hazardous waste sites, including ground water, surface water, sediments, soil, air, air borne particulates, oily wastes, pure or nearly pure chemicals and chemical sludges.

Selection of sample types is based on background studies and observations of current site conditions. The FIT Project Manager and EPA Project Officer should confer on the selection and locations of samples prior to work plan development.

5.3 ANALYTICAL SERVICES

The Contract Lab Program (CLP) is set up to handle both Routine Analytical Services (RAS) and Special Analytical Services (SAS). RAS analyses can only be performed on water, soil and sediment samples. Routine organic analyses include: volatiles (VOA); extractables (base/neutral/acids--B/N/A); and pesticides on the Hazardous Substance List (HSL). Routine inorganic analyses includes the 24 metals on the HSL and cyanide.

Other analytical parameters (e.g.: sulfides, anions, chromium VI) and matrices (e.g.: sludge, oily soil, air) require an SAS request.

The FIT Project Manager should be aware that more time is required to arrange for SAS analysis than RAS analyses. To arrange for RAS, requests for sample space must be made by the 15th of the month prior to sampling and must be confirmed by Tuesday of the week before sample shipment. Two weeks to one month more time may be required to arrange for SAS analyses, depending on the nature of the requested parameters.

The Project Manager and EPA Project Officer should discuss parameters needed to investigate a site. In many cases, a full scan of VOA's, B/N/A's and pesticides is not always warranted. The project manager should attempt to have sufficient background information available to reduce the parameter request or to add SAS parameters. For example, the need to include VOA analysis for surface soils and sediments should be evaluated carefully since those parameters have only a slight probability of being present. Field analytical screening will assist in making decisions about analytical requests.

5.4 SAMPLE CONTAINERS

Procedures for containing samples are guided by the sample matrix, the suspected level of concentration and analysis to be performed. The concept of high, medium and low concentrations is explained in Appendix 5-A. This appendix also defines sample terminology used in the sampling program.

Table 5-1 contains a listing of requirements for sample containers for various chemical parameters and concentration levels. This table includes container types, volumes and number of containers required.

5.5 SAMPLE PRESERVATION

Standard preservatives used by EPA for the preservation of low concentration water samples are listed in Table 5-1. Included in the table are the appropriate preservation procedures and holding times for each group of parameters. Preservation of low concentration organic sediments and soils includes cooling to 4°C only. Medium and high concentration waters, sediments and soils receive no preservatives and no cooling.

5.6 NOTIFYING LABORATORY OF HAZARD LEVEL

Hazard levels are determined by Region V FIT prior to field sampling activites. Sample analyses are set up through SMO prior to the field activities and are based in part on whether samples will be sent as low, medium or high concentration. If HNu, OVA or other screening devices indicate that a sample may be incorrectly categorized, this notation can be made on the corresponding traffic report forms (Section 10 of the organic traffic report and section 7 of the inorganic traffic report) and also on the appropriate Chain of Custody form. Field measurements of pH, conductivity and temperatures are routinely reported on the sample description forms. Readings from HNu or OVA instruments should also be noted on the sample description forms. See appendix 14-A for procedures for completing these documents.

Table 5-1
SAMPLE CONTAINER REQUIREMENTS PRESERVATIES AND HOLDING TIMES

Matrix Type	Analysis	Sample Concentration Level	Bottle Requirements- No.	Bottle Requirements- Description	Temperature Requirements	Preservative Requirements	Holding Times: Field to Lab**	Holding Times: Lab Analysis	Deliverables to CMPS* (days)	Minimum Volume	Requirements for MS/MSD Sample: No.	Requirements for MS/MSD Sample: Description
Water	Extractables RAS	Low	2	80-oz glass amber bottles	Cool to 4°C	Not Required	24 hr	5 days to extraction	30/40/45	1 gal	2	80-oz glass amber bottle
		Medium	4 or 8	32-oz wide mouth glass jars 16-oz wide mouth glass jars(1)	NR	NR	24 hr	" " "	30/40/45	1 gal	4 or 8	32-oz wide mouth glass jars 16-oz wide mouth glass jars
	Volatiles RAS	Low	2	40-mL glass vials	Cool to 4°C	NR	24 hr	7 days to analysis	30/40/45	80 mL	2	40-mL glass vials
		Medium	2	40-mL glass vial(1)	NR	NR	24 hr	" " "	30/40/45	80 mL	2	40-mL glass vials
Soils	Extractables RAS	Low	1	8-oz wide mouth jar	Cool to 4°C	NR	24 hr	10 days to extraction	30/40/45	6 oz	NR	NR
		Medium	1	8-oz wide mouth jar(1)	NR	NR	24 hr	" " "	30/40/45	6 oz	NR	NR
	Volatiles RAS	Low	2	120-mL glass vials	Cool to 4°C	NR	24 hr	7 days to analysis	30/40/45	240 mL	NR	NR
		Medium	2	120-mL glass vials(1)	NR	NR	24 hr	" " "	30/40/45	240 mL	NR	NR

*Dependent on CLP contract.
**May be held in the field for 3 days and shipped to the CLP lab as one case.
(1) Ship in 1-gal metal containers.

Table 5-1 (Cont.)

Matrix Type	Analysis	Sample Concentration Level	Bottle Requirements No.	Bottle Requirements Description	Temperature Requirements	Preservative Requirements	Holding Times: Field to Lab**	Holding Times: Lab Analysis	Holding Times: Deliverables to CMPS* (days)	Minimum Volume	Requirements for MS/MSD Sample No.	Requirements for MS/MSD Sample Description
Water***	Metals samples RAS	Low	1	1-L polyethylene bottle	Cool to 4°C	5mL of 1 to 1 (v:v) HNO_3	24 hr	30/35/45 (28 days mercury)	30/35/45*	1 L	NR	NR
		Medium	1 or 2	16-oz wide mouth jars(1) 8-oz wide mouth jars (1)	NR	" " " " "	24 hr	30/35/45	30/35/45	16 oz	NR	NR
	***Cyanide samples RAS	Low	1	1-L polyethylene bottle	Cool to 4°C	5mL of 50% NAOH	24 hr	" " "	" " "	1 L	NR	NR
		Medium	1 or 2	16-oz wide mouth jar(1) 8-oz wide mouth jars(1)	NR	" " " "	24 hr	" " "	" " "	16 oz	NR	NR
Soils	Metals & cyanide samples RAS	Low	1	8-oz wide mouth jar	Cool to 4°C	NR	24 hr	" " "	" " "	6 oz	NR	NR
	Metals & cyanide samples RAS	Medium	1	8-oz wide mouth jar (1)	NR	NR	24 hr	" " "	" " "	6 oz	NR	NR

*Dependent on CLP contract
**May be held in the field for 3 days and shipped to the CLP lab as one case.
***Monitoring well water for metal is filtered. All other water samples are not filtered.
(1) Ship in 1-gal metal containers.

Table 5-1 (Cont.)

Matrix Type	Analysis	Sample Concentration Level	Bottle Requirements No.	Bottle Requirements Description	Temperature Requirements	Preservative Requirements	Holding Times: Field to Lab	Holding Times: Lab Analysis	Holding Times: Deliverables to CMPS (days)	Minimum Volume	Requirements for MS/MSD Sample No.	Requirements for MS/MSD Sample Description
Water	High hazard samples RAS-SAS organics	High	1	120-mL glass vial (2, 3)	NR	NR	24 hr	45 days	45 days	120 mL	NR	NR
	High hazard RAS-SAS metals and cyanides	High	1	120-mL glass vial (2, 3)	NR	NR	" "	45 days	45 days	120 mL	NR	NR
Soils	High hazard RAS-SAS organics	High	1	120-mL glass vial (2, 3)	NR	NR	" "	45 days	45 days	120 mL	NR	NR
	High hazard RAS-SAS metals and cyanides	High	1	120-mL glass vial (2, 3)	NR	NR	" "	45 days	45 days	120 mL	NR	NR

(2) If the organic and inorganic high hazard sample is going to a single laboratory, ship only one vial If organic go to one lab and inorganic go to a 2nd lab, then supply one vial to the inorganic lab sand a second vial to the organic lab.

(3) Special shipping requirements

Table 5-1 (Cont.)

Matrix Type	Analysis	Sample Concentration Level	Bottle Requirements No.	Bottle Requirements Description	Temperature Requirements	Preservative Requirements	Field to Lab	Lab Analysis	Deliverables to CMPS (days)	Minimum Volume	Requirements for MS/MSD Sample No.	Requirements for MS/MSD Sample Description
Drinking water†	Semivolatile organic samples analyzed through RAS-SAS	Low	3	1-L amber glass bottles	Cool to 4°C	NR	24 hr	5 days	15/21 days(4)	3 L	3	1-L amber glass bottle
	Volatile organic samples analyzed through RAS-SAS	Low	2	40-mL glass vials	Cool to 4°C	NR	24 hr	7 days	15/21 days(4)	80 mL	2	40-mL glass vials
	Metal samples analyzed through RAS-SAS	Low	1	1-L polyethylene bottle	Cool of 4°C	5 mL 1 to 1(v:v) HNO_3	24 hr		15/21 days(4)	1 L	NR	NR
	Cyanide samples analyzed through RAS-SAS	Low	1	1-L polyethylene bottle	Cool of 4°C	5 mL of 50% NaOH	24 hr	1	15/21 days(4)	1 L	NR	NR

(4) Depends on available lab space
† Drinking water is non filtered.

Table 5-1 (Cont.)

Matrix Type	Analysis	Sample Concentration Level	Bottle Requirements No.	Bottle Requirements Description	Temperature Requirements	Preservative Requirements	Field to Lab	Lab Analysis	Deliverables to FIT (days)	Minimum Volume	Requirements for MS/MSD Sample No.	Requirements for MS/MSD Sample Description
Drinking water†	Semivolatile organic samples analyzed at CRL	Low	3	1-L amber glass bottles	Cool to 4°C	NR	24 hr	7 days	21 days	3 L	3	1-L amber glass bottle
	Volatile organic samples analyzed at CRL	Low	2	40-mL glass vials	Cool to 4°C	NR	24 hr	5 days	21 days	80 mL	2	40 ml glass vials
	Metals samples analyzed at CRL	Low	1	1-L polyethylene bottle	Cool to 4°C	5 mL 1 to 1 (v:v) HNO_3	24 hr	21 days	21 days	1 L		N/R
	Cyanide samples analyzed at CRL	Low	1	1-L polyethylene bottle	Cool to 4°C	5 mL of 50% NaOH	24 hr	21 days	21 days	1 L	NR	NR
	Mercury analyzed at CRL	Low	1	250-mL polyethylene bottle	Cool to 4°C	5mL of 0.05% (v:v) potassium dichromate & 0.5% (v:v) HNO_3	24 hr	21 days	21 days	250 mL	NR	NR

† Drinking water is never filtered.

TYPES OF SAMPLES FOR FIELD INVESTIGATIONS

The following terms for sample types are encountered in the SOP:

Environmental Sample. A sample of water, soil, or sediment which is associated with a hazardous waste site but is distant from the source of contamination or is dilute with respect to the concentration of the contaminants. For the purpose of this SOP, environmental samples are considered to be low concentration (hazardous) samples. These samples, by definition, contain less than 10 ppm of any single contaminant. Environmental samples do not require the special shipping procedures used with medium and high hazard samples. (See Chapter 14)

Concentrated (Hazardous) Samples. These samples are chemical materials or water, soil, or sediments containing elevated concentrations of contaminants. These types may include on-site samples obtained from surface impoundments (lagoons), pits, waste piles and containers, including drums, tanks, and tank cars. Based upon the best professional judgement of FIT personnel, these types of samples are sub- categorized as medium or high concentration samples.

Medium Concentration (Hazardous) Samples are collected in areas where there is evidence of direct but dilute contamination. The concentration range is generally between ten parts per million (ppm) and 150,000 ppm (15%) of hazardous material.

High concentration (Hazardous) Samples are collected directly from or near the source where there is evidence of undiluted contamination. The concentration range of the hazardous material is between approximately 150,000 ppm (15%) and 100%. This category includes all samples having no obvious or significant dilution by water, soil or any other non-toxic substance. Obtaining these samples poses the greatest risk of exposure to personnel. In addition, U.S. Department of Transportation (DOT) regulations require that these samples are shipped to a regulated substances laboratory where they may be safely prepared for analyses. (See Chapter 14) Currently, "Poison A" substances cannot be shipped via Federal Express or other delivery services.

Leachate Sample is a solution produced by the precolation of water through solid materials such as landfills, mine tailings piles or soils. Such as a sample may be either an environmental sample or a concentrated sample depending upon sereral factors (proximity to the source, concentration of the material in the source, infiltration rate of water, solubility, adsorptivity, etc.). These samples are usually collected as surface waters issuing from embankments or impoundment walls.

Background Sample is a sample (water, soil, or sediment) which is collected away from the contaminant source in a direction that is least likely to receive contaminants transported by wind, surface run-off or ground water movement. This sample is taken to be representative of conditions existing on the site before hazardous waste was deposited. Because it is used for comparison with concentrations of samples from the hazardous waste site in the Mitre Model Hazardous Ranking Score, great care is exercised in the selection of the control sampling location.

Potable Water Supply Sample is a sample collected from the domestic water supply. The supply may be a surface stream, ground water, or surface impoundment, may be either public or private and may not be treated prior to consumption. These samples may be analyzed by Region V Central Regional Laboratory.

Grab or Discrete Sample is an instantaneous collection of a single amount of a sample.

Composite Sample is a combination of individual samples taken over a period of time at a sampling point or combination of individual samples taken during one sampling event from several sampling points. The sample composite is collected by removing a fixed amount of the substance within a fixed time interval and combining it with other similarly collected amounts to produce a single sample for analysis. The proportioned composite is sometimes used for media with variable flow rates. Such a sample is collected either by varying the amount of sample with the flow or by varying the frequency of collection with flow. The site composite may be used in some circumstances. This method involves combining samples from different locations on the site into a sample which is composited. Such a sample may provide useful data about average concentrations of contaminants or about the presence or absence of hazardous substances at the site.

Split Sample is a sample which has been portioned into two or more containers from a single sample container.

Duplicate Sample is collected simultaneously from the same source, under identical conditions into separate containers. These samples are treated independently in order to assess laboratory performance by comparison of the results.

Field Blanks are samples of distilled, deionized, or organics-free water which are presumably free of contaminants. These samples are treated the same as actual site samples during collection in order to determine whether any contamination of samples has occurred as a result of faulty sample management practices. Blanks must be passed through decontaminated sampling equipment to evaluate field procedures.

Matrix Spike Duplicate is an additional organic sample volume collected at a specific sample location at a site. This extra volume provides the laboratory sufficient sample to duplicate their analyses on a given sample.

CHAPTER 6
QUALITY ASSURANCE IN SAMPLING

6.1 INTRODUCTION

A comprehensive quality assurance - quality control (QA/QC) plan is necessary to document the validity of all data which result from sample collection. Therefore, it is absolutely necessary to be able to follow events from the time of sample collection to its receipt by the laboratory. A comprehensive quality assurance program involves careful documentation of the work performed during the following phases of sampling:

- Sample program development
- Calibration and maintenance of field instruments
- Field analyses
- Techniques of sample collection
- Preservation and transport of samples
- Methods for checking laboratory precision
- Processing, verification, and reporting of data collected at the site.

This SOP for field sampling is designed to be a basis for quality assurance. Accordingly, elements of quality assurance for various phases of the sampling program are integrated into each chapter of this SOP. This chapter emphasizes certain important concepts which should be followed to assure that data of the highest quality are collected. These concepts are based on the Zone II REM/FIT Quality Assurance Manual.

6.2 QUALITY ASSURANCE BY SAMPLE PROGRAM DEVELOPMENT

Sampling program development involves the submission of a work plan to the EPA Region V Environmental Services Division Director for each site investigation conducted. (See Chapter 2)

The work plan includes justification for the choices of sampling sites, the numbers of samples to be collected, a summary of sampling procedures and analytical services required. This type of control allows ESD to review sampling logistics for each site before work commences and to evaluate the adequacy of the plan.

6.3 FIELD EQUIPMENT QUALITY CONTROL

6.3.1 Calibration and Maintenance of Equipment

A regular schedule for calibration of field sampling, reconnaissance and safety instrumentation and equipment is defined in E&E corporate manual entitled, "Calibration, Operation, and Maintenance Field Manual". This manual is in the FIT Library.

All instrumentation used in field activities must be calibrated prior to field use and periodically thereafter, according to E&E's corporate manual and the manufacturers' instructions. Where required, field instruments must be calibrated and reported at the beginning and end of each sampling day.

Continuous sampling devices must be calibrated according to manufacturer's specifications at the time of field set-up and checked as often as necessary. Sample lines for continuous devices must be cleaned or replaced prior to each installation.

In those instances when a field instrument will not calibrate, the instrument maintenance personnel will attempt a field repair of the impaired equipment. The equipment coordinator and instrument maintenance specialist is responsible for seeing that spare parts and other appropriate items for field equipment are available for field repairs and to minimize equipment down time. To the extent possible or practical, backup field equipment should be available.

Calibration of instruments is necessary to maintain properly operating equipment and to demonstrate that instrumental response is within the range of acceptability. Data from each calibration are transcribed into log books to preserve a record of calibration in case of later challenges and for proof of acceptability of collected field data.

- o date and time of calibration
- o brief statement of calibration procedures
- o names of persons calibrating the instrument
- o observed response of instrument
- o recommendations about instrument maintenance or repair

All log books are examined by the field team leader for comments regarding instrument response after returning from the field. Any necessary maintenance is immediately performed to assure that instruments are in proper operating condition prior to the next field use. All records of maintenance and repairs and names of individuals doing the work are logged in the instrument book and are reported to the regional equipment coordinator.

6.3.2 Elimination of Cross-Contamination

As a general rule, when several locations are to be sampled during one sampling trip and these locations include both "clean" and "contaminated" sites, separate collection equipment should be used at each location. When this procedure is not possible or the need for separate equipment has not been anticipated, sampling should progress from clean areas to the most suspected contaminated area. This procedure lessens the chance of unintentional contamination of cleaner samples through the use of contaminated sampling equipment. Equipment should be cleaned between sampling locations to prevent cross contamination. Decontamination procedures are discussed in Chapter 11.

6.4 QUALITY CONTROL TECHNIQUES FOR SAMPLE COLLECTION AND PRESERVATION

Procedures which ensure that representative samples are collected are discussed in the following chapters:

CHAPTER 8 - WATER SAMPLING
CHAPTER 9 - SOIL AND SEDIMENT SAMPLING
CHAPTER 10 - HAZARDOUS MATERIALS SAMPLING

Chapter 5 discusses the proper methods for preserving specific chemical species in samples and when adding preservatives is necessary.

Appendix A contains a copy of the field checklist developed by NEIC to evaluate contractor performance. All FIT members should be completely familiar with the contents of this checklist and pattern their field documentation after the elements addressed by it. Region V FIT has also developed sample shipment checklists to provide quality control in shipment of low, medium, and high concentration samples. These checklists are contained in Appendix B.

6.5 METHODS FOR CHECKING LABORATORY PRECISION

EPA has a formalized internal QA program in place for systematically checking the accuracy of EPA-Region V and contract laboratory results. The precision and accuracy of contracted laboratories are checked on a regular basis. FIT employs two types of quality assurance samples when conducting sampling activities. They are the duplicate sample and the blank sample. The duplicate sample which is the collection of two identical samples, provides a check on field and laboratory precision. The blank sample, distilled water sample, is a non-site sample of known characteristics.

Blanks, prepared by running distilled water through bailers, buckets, filters, etc., check the adequacy of the decontamination procedures used at the site and check bottle or laboratory induced contamination.

Region V sampling protocol requires that a duplicate sample be taken per ever 20 samples collected per site. A blank sample is required at every sampling site and if sampling occurs at a site over a period of several days, a blank is required each day. Based upon an ESD decision, FIT does not collect duplicates of soil or sediment samples.

In addition, there are sample collection requirements for CLP QA. For water samples, one organic sample should be taken at double the normal volume. This provides the CLP with a field sample and a matrix spike sample. All of these bottles go on the same traffic report. In the event that there are not enough traffic report stickers, the traffic report number can be written on tape and placed on the bottles. An entry should be included on the traffic report that the double volume is being provided for laboratory QC.

6.6 SAMPLE CONTAINER PROGRAM

An essential element of insuring overall sample quality is directly related to preparation of the sample container. FIT will collect samples in only new containers provided under the Sample Management Office's Bottle Repository Program.

Quality control procedures followed in preparation of sample bottles as specified in the Zone II REM/FIT Quality Assurance Manual.

Sample bottles are issued by lot number. Lot numbers for each bottle will be transcribed into the samples field log and chain of custody record. The report of sampling activities will correlate samples with their bottle lot numbers, sample tag numbers and traffic report numbers.

6.7 DOCUMENT CONTROL

Many investigations of sites containing hazardous substances will eventually support litigation under the enforcement provision of the Resource Conservation and Recovery Act of 1976 (RCRA Public Law 94-580) and the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund, Public Law 96-510). All information, data, samples and documents must be treated as evidence and must be retrievable when the project is completed.

The elements of document control are described in Chapter V-C of the NEIC document "Enforcement Considerations for Evaluation of Uncontrolled Hazardous Waste Disposal Sites by Contractors," April, 1984. Proper forms used in FIT sampling programs and explanations for completing them are contained in Chapter 14.

6.7.1 Serialized Documents

All observations and other pertinent data should be recorded in an individual serialized bound logbook. It is important that logbook entries be objective and that they are legible, dated, and signed by the person recording the information. Logbooks are helpful for completion of reports, for recall of events during possible future testimony, or for use by authorities if the investigator is no longer available. The same procedure applies to other field data records which are not written in logbooks such as well completion records, subcontractors' supply lists, geophysical data reduction sheets, strip chart recordings from analytical equipment, etc.

From time to time, the FIT Quality Assurance Officer will perform a quality assurance audit. An example of the audit report is provided in Appendix 6-C. The field logbook should contain all information as shown on this report sheet, at a minimum. Serialized sample identification tags make it possible for individual samples to have unique identifying codes which are recorded on the sample description forms for the project. A unique code makes sample handling and differentiation easier and gives a reference code for the laboratory to use when reporting analytical results. Completion of sample tags is addressed in Chapter 14.

6.7.2 Photographs

Photographs are important in documenting the cause-and-effect relationship of hazardous materials migrating off-site, especially in the areas of environmental damage and potential human exposure. Whenever samples are collected, photographs should be taken to verify the written description in the field logbook. Photographs should contain an object to portray the scale of the subject being photographed. In all cases where a photograph is taken, the following information must be written in the logbook:

(1) Time, date, location and, if appropriate, weather conditions.

(2) Complete description or identification of the subject in the photograph and reason why the photograph was taken.

(3) The sequential number of the photograph and the film roll number.

(4) Name of person taking photograph.

Actual photographs are more convenient than slides, but both the prints and the negatives must be controlled when the photographs are developed.

6.7.3 Corrections to Documentation

If errors are made during the recording of observations and other information, the error can be corrected at once by drawing a single line through the wrong information and entering the correct information. Any error corrected after the fact must have a single line through it and be signed and dated. Explanations of corrections should be done in a narrative style and must be complete.

6.7.4 Confidential Information

Any information which is given to an investigator and declared confidential should be treated as such. Justification for the confidential claim should be provided at the time of the claim. All confidential information should be stored in a separate locked file and recorded in a logbook for tracking purposes. Such information should be available on a need-to-know basis to appropriate persons, and a check-out system should be used to control access and prevent loss of records. Confidential information should not be reproduced except by approval of the person in charge of the documents.

Any data declared confidential according to the provisions of the Toxic Substances Control Act (TSCA, Public Law 94-469) should be received <u>only</u> by a person with the necessary specific clearance. All others should avoid this situation entirely.

6.7.5 Project File

After an investigation is completed, all information should be organized into a project file. Because this information may be needed as evidence in litigation, the data should be inventoried and tracked whenever it is removed from the file. Included in the file should be the project work plan, logbooks, filed records, all correspondence, report notes and calculation, references, miscellaneous documents (photos, maps, drawings, etc.) and the final report. Separate site files are maintained for sample documents, chain of custody records and analytical data.

APPENDIX 6-A

NEIC PROCEDURES MANUAL FOR THE EVIDENCE AUDIT OF ENFORCEMENT INVESTIGATIONS BY CONTRACTOR EVIDENCE AUDIT TEAMS

(FROM EPA-330/9-81-003-R, APRIL, 1984)

FIELD CHECKLIST

Briefing with Project Coordinator

SIGNATURE OF AUDITOR ________________ DATE OF AUDIT ______________

PROJECT COORDINATOR ________________ PROJECT NO. ______________

PROJECT LOCATION ____

TYPE OF INVESTIGATION (authority, agency) ____

Yes__ No__ N/A__ 1. Was a project plan prepared? If yes, what items are addressed in the plan?

____

____

____

Yes__ No__ N/A__ 2. Were additional instructions given to project participants (i.e., changes in project plan)? If yes, describe these changes.

____

____

____

Yes__ No__ N/A __ 3. Is there a written list of sampling locations and descriptions? If yes, describe where documents are.

____

____

____

Yes__ No__ N/A__ 4. Is there a map of sampling locations? If yes, where is the map?

____

____

____

Yes__ No__ N/A__ 5. Do the investigators follow a system of accountable documents? If yes, what documents are accountable?

____

____

____

Yes__ No__ N/A__ 6. Is there a list of accountable field documents checked out to the project coordinator? If yes, who checked them out and where is this documented?

____

____

____

Yes__ No__ N/A__ 7. Is the transfer of field documents (sample tags, chain-of-custody records, logbooks, etc.) from the project coordinator to the field participants documented? If yes, where is the transfer documented?

____

____

____

FIELD CHECKLIST

Field Observations

Yes__ No__ N/A__ 1. Was permission granted to enter and inspect the facility? (Required if RCRA inspection)

____

____

____

Yes__ No__ N/A__ 2. Is permission to enter the facility documented? If yes, where is it documented?

____

____

____

Yes__ No__ N/A__ 3. Were split samples offered to the facility? If yes, was the offer accepted or declined?

____

____

____

Yes__ No__ N/A__ 4. Is the offering of split samples recorded? If yes, where is it recorded?

____

____

____

Yes__ No__ N/A__ 5. If the offer to split samples was accepted, were the split samples collected? If yes, how were they identified?

____

____

____

Yes__ No__ N/A__ 6. Are the number, frequency and types of field measurements and observations taken as specified in the project plan or as directed by the project coordinator? If yes, where are they recorded?

____

____

____

Yes__ No__ N/A__ 7. Are samples collected in the types of containers specified for each type of analysis? If no, what kind of sample containers were used?

____

____

____

Yes__ No__ N/A__ 8. Are samples preserved as required? If no or N/A, explain.

____

____

____

Yes__ No__ N/A__ 9. Are the number, frequency and types of samples collected as specified in the project plan or as directed by the project coordinator? If no, explain why not?

____

____

____

Yes__ No__ N/A__ 10. Are samples packed for preservation when required (i.e., packed in ice, etc.)? If no or N/A, explain why.

____

____

____

Yes__ No__ N/A__ 11. Is sample custody maintained at all times? How?

____

____

____

FIELD CHECKLIST

Document Control

Yes__ No__ N/A__ 1. Have all unused and voided accountable documents been returned to the coordinator by the team members?

Yes__ No__ N/A__ 2. Were any accountable documents lost or destroyed? If yes, have document numbers of all lost or destroyed accountable documents been recorded and where are they recorded?

Yes__ No__ N/A__ 3. Are all samples identified with sample tags? If no, how are samples identified?

Yes__ No__ N/A__ 4. Are all sample tags completed (e.g., station no., location, date, time, analyses, signatures of samplers, type, preservatives, etc.)? If yes, describe types of information recorded.

Yes__ No__ N/A__ 5. Are all samples collected listed on a chain-of-custody record? If yes, describe the type of chain-of-custody record used and what information is recorded.

Yes__ No__ N/A__ 6. If used, are the sample tag numbers recorded on the sample description forms?

Yes__ No__ N/A__ 7. Does information on sample tags and Chain-of-Custody Records match?

Yes__ No__ N/A__ 8. Does the Chain-of-Custody Record indicate the method of sample shipment?

Yes__ No__ N/A__ 9. Is the Chain-of-Custody Record included with the samples in the shipping container?

Yes__ No__ N/A__ 10. If used, do the sample traffic reports agree with the sample tags?

Yes__ No__ N/A__ 11. If required, has a receipt for samples been provided to the facility (required by RCRA)? Describe where offer of a receipt is documented.

Yes__ No__ N/A__ 12. If used, are blank samples identified?

Yes__ No__ N/A__ 13. If collected, are duplicate samples identified on sample description forms?

Yes__ No__ N/A__ 14. If used, are spiked samples identified?

Yes__ No__ N/A__ 15. Are logbooks signed by the individual who checked out the logbook from the project coordinator?

Yes__ No__ N/A__ 16. Are logbooks dated upon receipt from the project coordinator?

Yes__ No__ N/A__ 17. Are logbooks project-specific (by logbook or by page)?

Yes__ No__ N/A__ 18. Are logbook entries dated and identified by author?

Yes__ No__ N/A__ 19. Is the facility's approval or disapproval to take photographs noted in a logbook?

Yes__ No__ N/A__ 20. Are photographs documented in logbooks (e.g., time, date, description of subject, photographer, etc.)?

Yes__ No__ N/A__ 21. If film from a self-developing camera is used, are photos matched with logbook documentation?

Yes__ No__ N/A__ 22. Are sample tag numbers recorded? If yes, describe where they are recorded.

Yes__ No__ N/A__ 23. Are calibration of pH meters, conductivity meters, etc., documented? If yes, describe where this is documented.

Yes__ No__ N/A__ 24. Are amendments to the project plan documented? If yes, describe where the amendments are documented.

FIELD CHECKLIST

Debriefing with Project Coordinator

Yes__ No__ N/A__ 1. Was a debriefing held with project coordinator and/or other participants?

____

____

____

Yes__ No__ N/A__ 2. Were any recommendations made to the project participants during the debriefing? If yes, list recommendations.

____

____

____

____

____

____

____

____

____

____

____

APPENDIX 6-B

SAMPLE SHIPMENT CHECKLISTS

Site Name: ____________
Location: ____________
Case Number: ____________

SAMPLE SHIPMENT CHECKLIST: LOW CONCENTRATION SAMPLES

Mark each item with an "X" to verify completion.

______ 1. Is each sample bottle permanently labeled with the following information: Sample number, date, time of collection, and a brief description?

______ 2. Are sample volumes marked on all sample bottles (except VOA's)?

______ 3. Is each sample bottle lid secured with strapping tape or evidence tape?

______ 4. Have all bottles been packed in plastic bags?

______ 5. Are all samples properly preserved and iced, when appropriate, for shipment?

______ 6. Are samples packaged in such a way as to prevent breakage?

______ 7. Has the proper cushioning material (ie-vermiculite) been used for sample packaging?

______ 8. Is each cooler drain taped shut?

______ 9. Have all coolers been labeled with the proper laboratory address and has this label been covered with clear tape?

______ 10. Has each cooler been labeled with "This Side Up" stickers on all four sides and "Fragile" stickers on at least two sides?

______ 11. Is there at least one Chain-Of-Custody record per cooler?

______ 12. Have the proper sections of the sampling paperwork been put in a plastic bag and taped to the inside lid of the coolers?

______ 13. Has each cooler been secured properly with strapping tape?

_____ 14. Have numbered custody seals been affixed to the front right and back left of each cooler and covered with clear tape?

_____ 15. Has the sampler double-checked all paperwork and packiging procedures for accuracy and completeness immediately prior to strapping each cooler for shipment?

_____ 16. Have photos of each cooler, showing ice, custody seals, and proper packaging procedures, been taken?

I certify that all the above procedures have been followed and that all coolers have been properly packaged for shipment.

X ____________________ Sampler Signature

X ____________________ Team Leader Signature

<u>NOTE:</u> If there is <u>any</u> question that one of the above has been done incorrectly by any member of your team, <u>DO NOT</u> ship samples without checking your suspicions (even if this means re-opening coolers that have already been strapped shut!)

45T:6M

Site Name: ________________

Location: ________________

Case Number: ________________

SAMPLE SHIPMENT CHECKLIST:
MEDIUM AND HIGH CONCENTRATION SAMPLES

Mark each item with an "X" to verify completion.

_______ 1. Have the outsides of all sample bottles been decontaminated?

_______ 2. Is each sample bottle permanentaly labeled with the following information: sample number, date, time of collection, and a brief description?

_______ 3. Is each sample bottle lid secured with strapping tape or evidence tape?

_______ 4. Are all samples placed in plastic bags and positioned so the tags may be read?

_______ 5. Is each sample packed in a metal can?

_______ 6. Is each metal can secured with <u>three</u> clips?

_______ 7. Does the outside of the can contain the following information: "This Side Up", DOT hazard class label, laboratory address and traffic number?

_______ 8. Has the proper cushioning material (ie-vermiculite) been used for sample packaging?

_______ 9. Has the correct proper shipping name and hazard class been selected for each sample being shipped?

_______ 10. Is each cooler drain taped shut?

_______ 11. Have all coolers been labeled with the <u>proper</u> laboratory address and has this label been covered with clear tape?

_______ 12. Does each cooler contain samples of only one hazard class?

_______ 13. Have all coolers been labeled and marked as required by DOT Regulations for that particular hazard class?

________ 14. Have all coolers been marked with the appropriate UN Number?

________ 15. Is there at least one Chain-Of-Custody record per cooler?

________ 16. Have the proper sections of the sampling paperwork been put in a plastic bag and taped to the inside lid of the cooler?

________ 17. Has each cooler been secured properly with strapping tape?

________ 18. Have numbered custody seals been affixed to the front right and back left of each cooler and covered with clear tape?

________ 19. Has the shipper completed a hazardous material certification form for each hazard class being shipped?

________ 20. Has the sampler double-checked all paperwork and packaging procedures for accuracy and completeness immediately prior to strapping each cooler for shipment?

________ 21. Have photos of each cooler, showing custody seals and proper packaging procedures, been taken?

I certify that all the above procedures have been followed and that all coolers have been properly packaged for shipment.

X ____________________ Sampler Signature

X ____________________ Team Leader Signature

<u>NOTE:</u> If there is any question that one of the above has been done incorrectly by <u>any</u> member of your team, <u>DO</u> <u>NOT</u> ship samples without checking your suspicions (Even if this means re-opening coolers that have already been strapped shut!)

45T:6M

APPENDIX 6-C

FIT AUDIT FROM FOR FIELD LOGBOOKS

SITE NAME: PROJECT OFFICER:

TDD: DATES OF ACTIVITY:

TYPE OF ACTIVITY :

QA OFFICER :

STRUCTURE OF FIELD LOG BOOK

1. Is purpose of sampling activity stated?

2. Does log book show location and description of samples?

3. Is reference map included?

4. Is sampling crew identified?

5. Is a daily activity log provided?

6. Are pages consecutively numbered?

7. Are entries in indelible ink?

8. Are errors lines through and corrections initialed?

9. Are pages signed or initialed?

10. Were the names and telephone numbers of field contacts recorded?

11. Have records of field calibrations been included?

12. Are the name of the shipping agent and shipping dates included?

AUDIT OF ENTRIES

Recorded Information:																									
Location																									
Type of Sample Matrix																									
Hazard Level Given																									
Sampling Method Described																									
Number of Bottles Listed																									
Volume of Samples Described																									
Preservatives Included																									
Sample ID Numbers Clear																									
Time & Date Given																									
Casing Description Provided																									
Volume of GW Purged Determined																									
Field Measurements																									
pH																									
Cond																									
Temp																									
Observations Recorded																									
Initials or Signature																									
Corrections Properly Made																									

CHAPTER 7
FIELD MEASUREMENTS

7.1 INTRODUCTION

This chapter presents stepwise methods for performing common field measurements for sampling programs. These measurements must be reliable since they indicate chemical or physical conditions at the point of sampling. All field measures should be performed on a separate aliquot of a sample or directly in the sample source. No measurements are to be taken from any bottle submitted for analysis. Measurements must be recorded in the field logbook.

7.2 FIELD MEASUREMENTS

Water Temperature - This measure is done on all water samples at the time and place of sampling. A mercury thermometer is placed in the sample source: flowing stream; continuously pumped ground water; or an aliquot of sample water. The thermometer is allowed to equilibrate with the water. A reading in degrees Celsius is recorded in the logbook. If desired, the measurement should be repeated.

Equipment: 250 ml container
mercury thermometer, Celsius scale.

Specific Conductance (Conductivity) of Water

1. Rinse measuring cell with distilled water, followed by rinsing with several volumes of sample water.
2. Fill cell with sample water, press "Test" button, and obtain reading, switching to proper scale.
3. Record reading and calibration readings in logbook. Generally, instruments have temperature compensation circuitry. If not, record sample, temperature and apply a correction.

4. Remeasure, if desired.

Equipment: Specific conductance meter
Distilled Water
(see Chapter 6 for calibration method.)

pH Water - This general procedure supplements the instruction provided by the instrument manufacturer. Before use, the instrument should be calibrated per the manufacturers instructions.

1. Rinse probe with distilled water. Rinse container with sample water.
2. Set temperature knob on instrument to $\pm$ 1°C of sample temperature.
3. Fill container with sample water.
4. Remove cap from probe and immerse in sample container, stirring to mix water. Turn instrument on.
5. Allow instrument to equilibrate (one minute). Record pH reading in logbook. Repeat measurement, if desired.
6. Rinse electrode in distilled water and replace cap

pH Soil

1. Calibrate the pH meter with two standard solutions
2. Prepare soil paste by adding distilled water to a soil sample while stirring with a spatula or spoon.
3. Stir paste until it reflects light and flows slightly when container is tipped.
4. Allow sample to stand for approximately one hour.
5. *Paste should remain quite viscous, if not, re-mix with more* soil.

6. Set temperature knob or instrument to $\pm$ 1°C of sample temperature.

CAUTION: If paste becomes too wet, inaccurate readings may result. If puddles appear, add more soil.

7. Obtain pH by moving probe up and down through the paste.

NOTE: Remember to adjust pH to compensate for soil temperature.

REFERENCE: Diagnosis and Improvement of Saline and Alkali Soils, Agricultural Handbook #60, U.S. Salinity Laboratory Staff, L.A. Richards, edition. February, 1954, pp. 84 and 102.

Equipment needed:

250 ml beaker
pH meter, 1 pH probe
Thermometer
Distilled water
Standard pH buffer solutions

Stream Measurements

- o Depth of a stream or pond (average). This may be limited to estimates, especially if access is restricted to the shoreline. If using a sounding device, such as a graduated pole, perform this measurement <u>after</u> the samples have been obtained.

- o Velocity of stream. This can be approximated by estimating the velocity of a floating object. Perform this measurement <u>after</u> samples are obtained.

- o Flow rate of stream. Cross-sectional area is estimated from depth and width of stream. The cross-sectional area may be estimated by assuming that the cross-sectional area of the stream is a triangle and using the formula A = 1/2 bh, where:

A = cross-sectional area
b = width of stream (ft)
h = depth of stream a deepest point (ft)

The cross sectional area is then multiplied by velocity (ft/sec) for an approximation of flow rate (ft^3/sec).

CHAPTER 8
WATER SAMPLING

8.1 INTRODUCTION

The surface water and groundwater routes are major components of the Hazardous Ranking System (HRS). Identification of a contaminant release in either of these routes could lead to listing the site on the National Priorities List (NPL). This chapter describes the equipment, methods of collection and sample site selection used when sampling surface water and ground water. Sampling methods are described for surface water, ground water, potable water supplies and industrial waste water.

Surface water and groundwater samples may be required to help in establishing the existence or extent of contaminant migration. Such data helps investigators to identify risks to populations and to determine appropriate remedial actions. Comparisons of water chemistry from sampling points upstream or upgradient to sampling locations both on-site and downstream from the site are used to evaluate contamination releases.

8.2 SURFACE WATER SAMPLING

8.2.1 Selection of Sampling Locations

Surface water sampling locations are selected on the basis of their probability for demonstrating contaminant migration. Prior to sampling, the surface water drainage in and around a site should be characterized using all available background information, including topographic maps and river basin studies. Air photos may be used to develop drainage maps which can then be confirmed by initial survey of the surface water adjacent to or on a site. An initial survey of potential sampling points is essential to the development of a work plan. Further, it is possible to anticipate any special equipment or personnel safety requirements which might be necessitated by terrain or other factors. The initial survey also allows field personnel to identify landmarks which locate sampling points, a crucial step in maintaining documentation of activities for legal actions.

In general, sampling locations may include rivers, creeks, or streams running through or adjacent to a site, including those bodies of water which may receive surface runoff or leachate from a site. Surface water samples may also be collected from lakes, stock watering ponds, or other types of impoundments.

The number of sampling locations is dependent on a variety of factors, including the size of a site and the availability of analytical support. An absolute minimum number would be two locations, one background and one downstream sample. Additional locations could be sampled to show concentration changes downgradient from the source; however, the HRS is mostly concerned with evidence of contaminant release, rather than concentration gradients. Sampling should include duplicates to provide the quality assurance for the program. (See Chapter 6.)

It is essential to establish the quality of water prior to its contact with the site. Surface drainage patterns should be carefully studied to determine background sampling locations. A minimum of one upstream sample is required for streams, although a background sample should be taken from <u>each</u> upstream surface water source entering the site. For standing bodies of water, a background sample may be obtained from a similar water body away from the suspected area of contaminant r•ease.

Ease of access to the sampling location is sometimes an important consideration when the samplers must carry a large amount of equipment to the site. Bridges sometimes provide good vantage points for sampling when composite samples are being collected. However, the need to sample point sources, such as stream flow from waste dumps, leachate breakouts, or drainages from mined areas may override site selection based on accessibility. Wading for water samples is not recommended in shallow lakes, ponds, and slow-moving rivers and streams because bottom deposits are easily disturbed resulting in increased sediment in the overlying water column. In slow moving, deep water, a boat is usually required for sampling.

Rivers, Streams, and Creeks. In the selection of surface water sampling sites on rivers, streams, and creeks, areas that exhibit the greatest degree of cross-sectional homogeneity should be located. When available, previously collected data may indicate if potential sampling locations are well mixed or vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately below riffle areas provides good vertical mixing. Horizontal (cross-channel) mixing occurs in constrictions in the channel. When several stations along a stream are to be sampled, they should be strategically located. Selection of sampling sites is often based upon accessibility, stream velocity, location of confluences, intake points for water supplies, and stream geomorphology.

Actual sample locations will vary with the size of the water body and the amount of turbulence in the stream or river. Generally, with small streams less than about 20 feet wide, a sampling site can be found where the water is well-mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross-section. (A sediment sample can also be collected in the center of the channel.) For slightly larger streams, at least one vertical composite should be taken from mid-stream, with samples taken just below the surface, at mid-depth, and just above the bottom. Measurements of pH, temperature and conductivity are made on each aliquot of the vertical composite. Dissolved oxygen is an optional parameter. Several vertical composites should be sampled in rivers. These vertical composites should be located in a manner that is roughly proportional to flow, i.e., they should be closer together toward mid-channel, where most of the flow travels, than toward the banks, where the proportion of total flow is smaller. The number of vertical composites required and the number of depths sampled for each are usually determined in the field by the sampling crew. This determination is based on a reasonable balance between two considerations:

- o The larger the number of subsamples, the more nearly the composite sample will represent the water body.
- o Taking many subsamples is time-consuming and expensive, and increases the chance of contamination.

More detailed descriptions of statistical basis for selecting surface water sampling sites are found in Handbook for Sampling and Sample Preservation of Water and Wastewater (EPA, Sept. 1982).

Lakes, Ponds, and Impoundments. Sampling locations may include any adjacent standing bodies of water such as lakes, stock watering ponds, sediment or flood control ponds, marshes, or ox-bow lakes which might be receiving contaminants. The number of water sampling sites on a lake, pond, or impoundment will vary with the depth, size and shape of the basin. Procedures for collecting samples from impoundments on hazardous waste sites should be evaluated if high concentrations of contaminants are indicated.

Standing surface waters have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more subsamples be obtained. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. In naturally formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam.

In lakes and larger impoundments, several vertical aliquots may be composited to form a single sample. These aliquots are often taken along a transect or grid. Again, the number of vertical composites and the depths at which samples are taken are usually at the discretion of the sampling crew. In some cases, it may be of interest to form separate composites of zones above and below the thermocline in a lake but normally a composite consists of several verticals aliquots with subsamples collected at various depths.

Lakes with irregular shapes and with several bays and coves that are protected from the wind may require additional separate composite samples to represent water quality adequately. Similarly, additional samples should be taken where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Leachates. Leachates can be formed by the mixing of rain water with wastes. A leachate may enter groundwater systems causing deterioration of the water quality. In areas where the ground surface slopes steeply away from the buried wastes, the leachate may "break out" or emerge on the ground surface. This situation is typically encountered at landfills or at the foot of mine tailings disposal piles. Samples taken from leachate streams may have to be treated as medium or high concentration samples depending upon the field evaluation.

8.2.2 Surface Water Sampling Equipment

The equipment needed for surface water sampling during investigations of hazardous waste sites is minimal. In most instances, the sample container serves as the sampling device. The use of highly sophisticated or automatic sampling devices is normally not required for routine site investigations.

Chapter 4 contains a list of suggested surface-water sampling equipment and accessories. Field personnel are encouraged to draw upon their own and other's experience to supplement this list. As a general precaution, any newly obtained container or sampling device must be thoroughly cleaned prior to use and between sample locations to avoid cross contamination (See Chapter 11). It is necessary that devices or containers for samples for organic compound analysis be made of glass, Teflon, or stainless steel. Stainless steel or PVC may be used to obtain samples for inorganic analyses.

Several types of sampling devices are available for collecting surface water samples. The Nansen bottle, DO dunker, Kemmerer sampler and Van Dorn sampler are different types of samplers. The selection depends upon the method of sampling and the intended analyses.

8.2.3 Surface Water Sampling Techniques

Most samples taken during FIT site investigations are grab samples. Typically, surface water sampling involves immersing the sample container in the body of water; however, the following suggestions will help ensure that the samples obtained are representative of site conditions.

- o The most representative stream samples are obtained from mid-channel at 0.6 stream depth in a well-mixed stream.

- o Stagnated areas or pools in a stream or river might contain zones of varying pollutant concentrations, depending upon the physical/chemical properties of the contaminants and the proximity of these stagnated areas to the site.

- o When sampling running water, it is suggested that sampling progress from downstream to upstream to eliminate sediment disturbance in subsequent samples. When samples are collected directly in sample bottles, there will be no concern for cross-contamination if high contaminated areas are sampled first.

- o To sample a pond or other standing body of water, the surface area may be divided into grids. A series of samples taken from each grid is combined into one sample, or several grids may be selected at random.

- o Care should be taken to avoid excessive agitation of the water during transfer from source to bottle. Agitation could result in the loss of volatile constituents.

- o When obtaining samples in 40 ml septum vials for volatile organics analysis, it is important to exclude any air space in the top of the bottle and to be sure that the Teflon liner faces in after the bottle is filled and capped. The container should be slowly filled to overflowing. After sealing, the bottle should be turned upside down and shaken to check for air bubbles. If air bubbles are present, the bottle should be filled with more sample and resealed.

- Do not sample at the water surface, unless sampling specifically for a constituent which is immiscible and on top of the water. Instead, the sample container should be inverted, lowered to the approximate depth, and held at about a 45-degree angle with the mouth of the bottle facing downstream.

- When sampling a small stream, seep, spring, pool, etc., the water may be too shallow or inaccessible to utilize the sample bottle for direct collection of the sample. Instead, a stainless steel ladle may be dipped into the water and the water transferred into the sample bottle. Care should be taken to minimize agitation of the sample during transfer.

8.3 GROUND WATER SAMPLING

8.3.1 Selection of Sampling Locations

Groundwater sampling locations are determined by the location of existing wells. It is important that the installation of any new wells be under the direction of an experienced hydrogeologist.

Generally, groundwater sampling locations are monitoring, residential, and industrial wells which are near or on a site. Many landfills typically have monitoring wells in place, and in areas with no municipal water supplies, most residences have their own wells. In urban areas, many industries whose processes require large amounts of water have their own production wells, and many municipalities rely upon large production wells. The need for an exhaustive background information search is stressed. The background search helps to identify well locations around a site and may provide information about the total depth, the depth to water, the well diameter and water use of the wells.

Existing monitoring wells may prove useful to a current project as either additional monitoring wells or piezometers. However, the utility of an existing monitoring well is dependent upon its construction and the integrity of the well. It is important to know the construction specifications to ensure that the existing well is consistent with objectives of the current project e.g., glued PVC joints are unacceptable if analyzing for organics. The integrity of the well must also be determined to guarantee the reliability of any samples collected from that well. If the above criteria can be met, existing monitoring wells may be utilized to supplement a proposed hydrogeologic study or replace planned well installation.

Usable existing monitoring wells should be sampled and analyzed prior to implementing a hydrogeologic study. This will establish the nature of any contaminants in the groundwater and assist in determining the need for additional sampling. Existing analytical data for the monitoring wells should be evaluated with the other site-specific information to determine the need for sampling other wells farther away from the site. Existing data may also enable the investigative team to key on a particular type of contaminant, thus reducing the amount of analytical support required.

Before sampling monitoring wells at a hazardous substance site, the placement of each well and previous data should be carefully evaluated. Samples collected from some wells have the potential to produce a highly concentrated sample. These locations should be identified in the sample plan since they may require personnel protection, including the use of respirators. Also, such information will assist in proper shipment to a laboratory capable of handling hazardous samples.

It is very important to assess the direction of groundwater flow. This may be accomplished by studying available hydrologic data describing the direction of groundwater flow near a site, but may require the use of geophysical techniques and the installation of additional monitoring wells. To assess subsurface conditions accurately, a minimum of three wells are required, placed in a triangle around the waste site. One of these wells should be installed in the expected upgradient direction from the site. In some cases, a system of wells may be needed to define the subsurface conditions, especially in establishing the direction of flow in multi-aquifer systems. Site conditions and the scope of the project will determine the total number of wells required. Drilling into the waste disposal area proper should be avoided. Drilling into waste disposal areas requires safety precautions essential to drilling crew safety. In addition, extensive precautious must be implemented to prevent accidental mobilization of contaminants resulting from drilling activities. Drilling and well installation procedures are presented in Chapter 16.

8.3.2 Groundwater Sampling Equipment

Chapter 4 contains a list of groundwater sampling equipment suggested for sampling operations. The use of more sophisticated methods and/or sampling equipment is beyond the scope of typical site investigations and is not addressed here. It is recommended that the equipment be kept to a minimum, since the access to many wells may be difficult.

ment efforts. The rope should be of more than sufficient length to allow for water level drawdown while sampling. To acclimate the bailer to the well water, the initial three (3) to five (5) bails should be properly wasted. When transferring the sample water from the bailer to the appropriate sample containers, care should be taken to avoid agitation which promotes the loss of volatile constituents. Bottom-draw bailer designs with dual checks valves and syringe samplers minimize these sources of bias.

After the well has been sampled, the bailer should be cleaned by washing with water, rinsing with acetone, and rinsing with distilled water. The rope and plastic sheet should be properly discarded as provided in the site safety plan and new materials provided for the next well.

SAMPLE FILTERING REQUIREMENTS

Once the groundwater sample is obtained, the following filtering protocol will be used prior to packaging and preservation.

Organic Samples	
VOA's	Non Filtered
BNA's	Non Filtered
Pesticides/PCB	Non Filtered
Inorganic Samples	
Dissolved Inorganics (except CN)	Filtered within 20 minutes
Total Inorganics	Non Filtered
Any Suspected Medium or High Hazard Sample	Non Filtered

The standard ground water filtration system consists of .masterflex peristaltic drive pump and a .45 micron millipore membrane filter. After each sample is filtered the barrel filter is thoroughly decontaminated and a new membrane filter installed. If any deviation to this policy is necessary the particulars should be noted in the site work plan.

8.4 POTABLE WATER SAMPLING

8.4.1 Sampling Site Selection and Sampling Techniques

Even though the same techniques used in wastewater and groundwater sampling (including thorough documentation of location, date, time, etc.) are used in potable water supply sampling, there are certain additional procedures which are used.

When water samples are collected from wells, either by mechnaical or hand pumping, the wells must be purged before the sample is collected (see the Groundwater Sampling seciton of this chapter). Residential wells often have holding tanks which must also be evacuated. This procedure insures that water in the aquifer is sampled, and not the standing water in the pump or holding tank. Information about well construction (casing diameter, static water level, total depth, pump rate) and holding tank is used to calculate the volume of water which must be purged before sampling. If that information is not avilable, a 15-20 minute evacuation period is the minimum acceptable time. Flow rate should be measured during purging.

Potable water samples must be representative of the water quality within a given segment of the distribution network. Taps selected for sample collection should be supplied with water from a service pipe connected directly to a water main in the segment of interest and should not be separated from the segment of interest by a storage tank.

The sampling tap must be protected from exterior contamination associated with being too close to the sink bottom or to the ground. Contaminated water or soil from the faucet exterior may enter the collection container during the sampling procedure, since it is difficult to place a bucket underneath a low tap without grazing the neck interior against the outside faucet surface. Leaking taps that allow water to flow out from around the stem of the valve handle and down the outside of the faucet, or taps where water tends to run up on the outside of the lip should not be sampled. Water samples collected from wells at residences or municipal water supplies should be obtained from outlets as close as possible to the pump. These samples should not be collected from leaky or faulty spigots. Aerators, strainers, and hose attachments on the tap must be removed before sampling. In addition, all samples should be collected prior to any filter, water softening devices or pressure tanks if at all possilble. A steady-flowing water stream at moderate pressure is desirable in order to prevent splashing and dislodging particles in the faucet or water line. Samples should be taken directly into the sample bottles to avoid excessive agitation and loss of volatiles.

Regardless of the type of sample bottle being used, the bottle caps should not be placed on the ground or in a pocket. Instead, hold the bottle in one hand the cap in the other, keeping the bottle cap right side up (threads down) and using care not to touch the inside of the cap. Avoid contaminating the sample bottle with fingers or permitting the faucet to touch the inside of the bottle. When sampling for bacterial content, the bottle should not be rinsed before use. When filling any container, care should be taken so splashing drops of water from the ground or sink do not enter into either the bottle or cap. Do not adjust the stream flow while sampling in order to avoid dislodging some particle in the faucet.

When sampling at a water treatment plant, samples should be collected both from the raw water supply and after chlorination.

The time of sample collection as well as the field test results for temperature, pH, and conductivity should be recorded. Any deviation from standard sampling practice should be also recorded. The name(s) the resident or water supply owner/operator and the resident's exact mailing address, as well as the resident's home and work telephone numbers are always entered into the sampling logbook. The information is required so that the residents or water supply owner/operators can be informed of the results of the sampling program.

8.4.2 Sampling Equipment

Sampling equipment and specific equipment quality assurance techniques are contained in Chapters 4, 6 and 7 of this SOP.

8.5 WASTE WATER SAMPLING

8.5.1 Selection of Sampling Locations

Where applicable, wastewater samples should be collected at the location specified in the NPDES permit (if the source has such a permit). In some instances the sampling location specified in the permit or the location chosen by the permittee may not be adequate for the collection of a representative wastewater sample. In such instances, the project leader or field investigator is not precluded by permit specifications from collecting a sample at a more representative location. Where a conflict exists between the permittee and the regulatory agency regarding the most representative sampling location, both sites should be sampled, and the reason for the conflict should be noted in the inspection or study report. Recommendations for any change in sampling location should be given to the appropriate permitting authority.

Influent. Influent wastewaters are preferably sampled at points of highly turbulent flow in order to insure good mixing; however, in many instances the most desirable location is not accessible. Preferred sampling points for raw wastes include:

- o The upflow siphon following a comminutor (in absence of grit chamber);
- o The upflow distribution box following pumping from main plant wet well;
- o Aerated grit chamber;
- o Flume throat; and

- Pump wet well.

In all cases, samples should be collected upstream from recirculated plant supernatant and sludges, and the sample collected should be completely untreated.

Effluent. Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering waste streams prior to discharge into the receiving waters.

Pond and Lagoon Sampling. Generally, composite samples should be employed for the collection of wastewater samples from ponds and lagoons. Even if the ponds and lagoons have a long retention time, composite sampling is necessary because of the tendency of ponds and lagoons to short circuit. However, if dye studies or past experience indicate a homogenous discharge, a grab sample may be taken as representative of the waste stream.

8.5.2 Sampling Techniques for Wastewaters

Some important considerations for obtaining a representative wastewater sample include:

- The sample should be collected where the wastewater is well mixed. Therefore, the sample should be collected near the center of the flow channel, at a depth between 0.4 - 0.6 ft. total depth, where the turbulence is at a maximum and the possibility of solids settling is minimized. Skimming the water surface or dragging the channel bottom should be avoided;

- In sampling from wide conduits, cross-sectional sampling should be considered. Dye may be used as an aid in determining the most representative sampling point(s); and

- If manual compositing is employed, the individual sample bottles must be thoroughly mixed before pouring the individual aliquots into the composite container.

Procedures for sampling wastewaters are outlined in the NPDES Compliance Sampling Inspection Manual. Additional guidance is given in the Agency's handbook, Monitoring Industrial Wastewater.

Sampling Techniques - General. Sampling and flow measuring are integrally related. The investigator must know the wastewater flow variability before a sampling program can be initiated. Therefore, prior to sampling, the flow system (primary flow device, totalizer, recorder) should be examined. If the flow measuring system is unacceptable, the investigator may have to install a system. If the flow measuring system is acceptable, the following options are available for sample collection.

If the flow does not vary by more than ± 15 percent, a time composite sample will be considered representative of the wastewater flow. (However, it is preferable to always collect a flow proportioned sample, if possible.) Time composite samples are based on a constant sample volume with a constant time interval between samples. A time composite sample can be collected either manually or with an automatic sampler.

If the flow varies by more than ± 15 percent, a flow proportioned sample must be collected. This can be done automatically with a compatible automatic sampler and a pacing flow measuring device, semiautomatically with an automatic sampler capable of collecting discrete samples along with a flow chart, or manually.

CHAPTER 9
SOIL AND SEDIMENT SAMPLING

9.1 GENERAL

The analysis of soil and sediment at a hazardous substance site sometimes provides valuable information about the existence and extent of contaminant migration. Consideration should be given to factors which contribute to dilution of a contaminant in soils and sediments such as oxidative or photochemical degradation, biological degradation, scouring and spreading by surface runoff and streams, and spreading due to infiltration by surface water. This chapter focuses on those samples which would be considered environmental samples. (See Chapter 10 for guidance on obtaining and handling concentrated [hazardous] soil and sediment samples.)

Soil and sediment properties vary not only from one location to another, but also among the horizons of a given profile. The variation of the soil and sediment must be taken into consideration during the design of the sampling plan. The project officer needs to develop a concise objective of why the study is needed and what questions the study is to answer.

For HRS sampling the bias sampling method will be used. A background sample is required for HRS sampling since the MITRE model requires the presence of contamination, with reference to background.

For non-HRS sampling, the project team leader must decide on the type of sampling situation that is dictated by site circumstances and whether a bias sampling method or a statistical sampling method is required. Both type of sampling methods should include an appropriate background (control) sample. It is also important that field personnel determine whether soil or sediment samples require handling as hazardous (concentrated) or environmental samples.

9.2 BIAS SAMPLING

The bias sampling approach is commonly practiced in FIT investigations. Samples are collected where spills or leaks of contaminants may have occurred. Investigators can determine these areas from site records or photographs or on direct observation of stained soils or areas lacking vegetation. (If soil is receiving a constant discharge of material, samples taken should be treated as hazardous/concentrated samples.)

9.2.1 Surface Sampling

Surface sampling under bias conditions may be selected after considering factors such as type of pollutant, length of time the area has been contaminated, the type of soil and the past use of the area. If the pollutant is easily sorbed, the spill or leak is recent, and the soil has a high affinity for that particular pollutant, surface sampling may be appropriate. Surface sampling usually includes the upper 6 inches of soil.

Sampling Techniques and Equipment for Surface Sampling

A. Grab Sample

- o The most desirable sample collection devices would be the soil auger (oakfield tube, king tube) or stainless steel bulb planters. These devices allow uniform sample depths to be achieved.

- o Alternative sample collection devices include stainless steel scoops or hand trowels and teflon trowels. These devices often produce inconsistent sample depths.

B. Composite Sampling

- o The most desirable method of compositing soil subsamples is with a large disposable aluminum pan. The subsamples are mixed in the pan. After the soil is mixed, it is spread out uniformly in the pan. The sample is quartered. A small scoop is used to collect small samples from each quarter until the desired amount of soil is acquired. (High concentrations of organic chemicals in soils can react with the plastic sheet.)

- An alternative method of compositing soil subsamples is to mix them in a stainless steel bowl. Subsamples are placed in the bowl and mixed using a stainless steel scoop. The soil is spread evenly in the bottom of the bowl after the mixing is complete. The soil is quartered and a small sample taken from each quarter.

- Subsamples are often collected in a fivepoint (star) pattern. At each point, a subsample of a predetermined depth is collected. The diagonal distance between points is commonly 10 feet depending on the area of soil homogeneity.

- Subsamples can also be collected in a three-point (triangular) pattern. At each point, a subsample of predetermined depth is collected. The diagonal distance between the points is commonly 10 feet depending on the area of soil homogeneity.

9.2.2 Subsurface Soil Samples

The need for biased sampling of subsurface soils should be evaluated by considering factors such as the precipitation, the type of pollutant, the type of soil and the length of time the site has been contaminated. If precipitation has moved pollutants into lower soil horizons, subsurface sampling may be appropriate. Subsurface sampling includes soil depths greater than 6 inches.

Subsurface Sampling Techniques and Equipment

Subsurface sampling can also be composite or grab sampling similar to surface sampling techniques.

A. Shallow Subsurface Sampling

- o The hand auger may be used to collect subsurface samples up to 4 or 5 feet in depth. The auger is twisted or screwed into the soil. The auger destroys the soil's cohesive structure and stratigraphic character. The bucket auger and blade auger are larger diameter augers which will collect larger samples if they are needed.

- o The soil probe may be used to collect subsurface samples up to 3 or 4 feet in depth. The probe is hollow and pushed into soil. The probe collects samples which are considered undisturbed although in reality, the portion of the soil adjacent to the tube may be smeared along the column.

- o The hand driven split-barrel sampler (split-spoon) may be used to obtain an undisturbed soil column up to 4 or 5 feet in depth. The sampler is threaded onto a drill rod and driven with a heavy hammer striking a drive plug threaded into the upper drill rod end.

- o The hand held power auger (i.e., post hole digger) may be used to collect subsurface soil samples, measure cover or strata thickness, etc. The practical depth limitation is approximately 10 feet. The auger is twisted or screwed into the soil, removing cuttings as it advances. The hand held power auger can be used in conjunction with a soil probe or split spoon.

- o The portable power cathead and tripod assembly may be used to collect subsurface samples to a practical depth of up to 10 or 12 feet. The cathead is a gasoline driven rotating drum (i.e., "head") that is attached to an aluminum tripod of 12 feet in length. By means of a rope/pulley system, a sampling device (i.e., split-spoon) can be suspended and then driven into the soil by a 140 pound hammer to obtain a sample.

B. Deep Subsurface Drilling

- Deep subsurface drilling and sampling techniques are presented in Chapter 16, Appendices C and D.

9.3 STATISTICAL SAMPLING

The statistical sampling technique is often used to determine an average concentration, a measure of data reliability, the direction of movement and the location of "hot spots". Through statistical sampling, it is possible to determine how many samples should be collected over a specific area within a given level of confidence. However, to determine the number of samples required to produce statistically valid data, it is necessary to know the variability in the analytical results. Therefore, in certain instances a small scale sampling program may be required to estimate data variability. (See Preparation of Soil Sampling Protocol: Techniques and Strategies by Benjamin Mason.)

9.3.1 Simple Random Sampling

Random samples are selected by some method that uses chance as the determining factor for selection. The random sample is free of selection bias. The total number of possible samples is determined by dividing the total area of the study boundaries by the cross sectional area of the soil core. Simple random sampling does not produce results with good precision due to the large statistical variations encountered in soil sampling. Simple random sampling is useful when more than one method of sampling is being used or when there is very little information about a site.

9.3.2 Stratified Random Sampling

Stratified random sampling is similar to random sampling, however it increases the precision of the estimates made by sampling. Stratification is made between soil types, soil textures, soil practices or soil horizons. The strata are selected so that the units within each stratum are more homogenous than the total population. Each stratum is handled as a separate simple random sampling effort.

9.3.3 Systematic Sampling

Systematic sampling provides better coverage of the soil study area than simple random sampling. Samples are collected in a regular pattern (usually a grid) over the area under investigation. The optimum sampling is obtained with a triangular grid; however, a square grid is often used because it is easier to set up in the field. The grid orientation in the field is selected randomly as is the starting point on the grid.

9.4 BACKGROUND (CONTROL) SAMPLE

The purpose of a background sample is to serve as a base line with which the results of the soil sampling study can be compared. The most important factor in choosing a background sample should be the soil type. The soil type should be similar to the other soil sampling sites. Similar vegetation type and depth to ground water should also be considered.

It is important that all equipment coming in contact with the soil be decontaminated between sampling locations. The equipment should be detergent-washed and rinsed with distilled water. If the presence of organic compounds is suspected, a solvent such as acetone should be used followed by rinsing with organic-free water.

9.5 SEDIMENT SAMPLES

Sediment samples are valuable for locating pollutants of low water solubility and high soil binding affinity. Where surface water might show trace quantities of contaminants, thus leading investigators to believe that off-site contaminant migration is minor, the analysis of sediments might show otherwise. Heavy metals and high molecular weight hydrocarbons are examples of contaminants which might be found in greater concentrations in sediments than in the stream water.

It is important to note that the sediments obtained from surface impoundments, such as lagoons, which are suspected to be highly concentrated are to be handled and treated as hazardous (concentrated) samples (see Chapter 10). This section addresses collecting those samples that can be treated and handled as environmental samples.

9.5.1 Approach for Sediment Sampling

The review of background information gives an indication of the types of substances which may be present in sediments. The following items should be considered when sampling.

- o Many pollutants adsorb onto sediments having a large surface-to-volume ratio. Therefore, silts and clays will contain higher concentrations of organics and trace metals than coarser sediments such as sands and gravels.

- o Hydrogeologic information should be noted which can help establish a relationship between the contaminant source and the contaminants in sediments.

- o Samples for organic analyses should not be collected from areas exposed to the air during periods of low flow or low recharge.

- o The pH of the surface water over the sediments should be determined to identify any unusual pH conditions which would influence contaminant retention by the sediments.

- Sediment samples should be obtained from the area nearest the suspected contaminant point source.

- A background sediment sample should be obtained from sediments upstream from the suspected point source for running water and from sediments away from the suspected point source for standing surface water. In cases of high contamination of small bodies of standing water, it may be impossible to find a background sample. The analysis of background sediments attempts to establish the contribution of the source to contaminant levels in the area.

9.5.2 Sediment Sampling Techniques

Very simple techniques can usually be employed for sediment sampling. Most samples will be grab samples, although sometimes sediment taken from various locations may be combined into one sample to reduce the amount of analytical support required. Suggested techniques include the following:

- In small, low-flowing streams or near the shore of a pond or lake, a sample container (8-ounce wide-mouth jar) may be used to scrape up the sediments. Collect 4 to 8 ozs. of material.

- To obtain sediments from larger streams or farther from the shore of a pond or lake, a Teflon beaker attached to a telescoping aluminum pole by means of a clamp may be used to dredge sediments. In most circumstances, a number of sediment samples should be collected along a cross-section of a river or stream in order to characterize the bed material adequately. A common procedure is to sample at quarter points along the cross-section of the site selected. When the sampling technique or equipment requires that the samples be extruded or transferred at the site, they can be combined into a single composite sample. However, samples of dissimilar composition should not be combined, but should be stored for separate analysis in the laboratory.

- To obtain sediments from rivers or in deeper lakes and ponds, a spring-loaded sediment dredge or benthic sampler may be used by lowering the sampler to the appropriate depth with a rope. The sediments thus obtained are placed into the sample container. When collecting sediment samples in lakes, ponds, and reservoirs, the site selected should be approximately at the center of water mass. This is particularly true for reservoirs that are formed by the impoundment of rivers or streams. Generally, the coarser grained sediments are deposited near the headwaters of the reservoir, and the bed sediments near the center of the water mass will be composed of fine-grained materials. The shape, inflow pattern, bathymetry, and circulation must all be considered when selecting sediment sampling sites in lakes or reservoirs. In rivers or streams, fine grained sediments are deposited on the inside of bends and downstream from islands and other obstructions.

- The sampling device should be decontaminated between locations.

CHAPTER 10

COLLECTION METHODS FOR MEDIUM AND HIGH HAZARD SAMPLES

10.1 OVERVIEW

In order to assess the hazard potential of a site, it is necessary to obtain samples which may contain up to 100% concentration of a contaminant. Depending upon the type of container the material is in and/or location of the sample, the risk of personnel exposure to contaminants is greater than at any other time during the field investigation. It is therefore important to take steps to protect sampling personnel properly and to use sampling equipment and methods which minimize the risk of exposure.

The criteria listed below identifies important factors which must be considered in selection of methods and/or equipment for use in obtaining hazardous samples. Although no one method or piece of equipment may meet all the criteria listed below, these criteria should be considered in evaluating methods or equipment.

- o Personnel dressed in Level A and B protection should be able to use the method/equipment selected without compromising their safety.

- o The method/equipment selected must avoid the possibility of causing synergistic reactions.

- o The method/equipment selected must avoid the possibility of sample cross-contamination.

- o The equipment selected should be easily decontaminated or, preferably, disposable.

- o The method/equipment selected should be time and cost effective.

10.2 APPROACH TO SAMPLING

10.2.1 Hazardous Substance Sample Containers

The quantity of sample required for a hazardous substance is typically less than the quantity required for environmental samples. The Environmental Protection Agency's (EPA) National Enforcement Investigations Center (NEIC) recommends a sample container of a capacity of eight ounces or less for most concentrated samples. Certain United States Department of Transportation (DOT) shipping regulations also affect the type of container selected (See Appendix 14-B). A glass bottle with a Teflon-lined non-metal screw cap is the recommended sample container for unanalyzed samples obtained from concentrated sources or closed containers where reliable information excludes the possible presence of a substance designated as "Poison A' by DOT. The use of a wide-mouth jar renders the task of placing the sample into the bottle easier for personnel wearing protective equipment. Neither FIT (nor the EPA), at the present time is equipped to ship Class A poisons. If a hazardous waste sample is thought to contain such a poison, it must not be shipped under the FIT contract.

Refer to Chapter 13 for guidance on the management and disposal of materials derived from field investigations and sampling activities.

10.2.2 Hazardous Substance Sampling Equipment

Table 10-1 is a list of suggested equipment for obtaining samples of hazardous substances. Other equipment can be used, but it should be disposable or easily decontaminated.

10.2.3 Hazardous Substance Sample Locations

The locations of hazardous samples will be determined by the disposal practices at a given site. Typically, they may include all of, but not necessarily be limited to, the following:

TABLE 10-1 LIST OF SUGGESTED EQUIPMENT

The following list of equipment is recommended. Innovations for unique situations are encouraged, provided they do not compromise personal safety or sample integrity.

4-foot lengths of glass tubing with bore size ranging from 6 mm to 20 mm. (Lengths of polyethylene tubing should be available if caustics or hydrofluoric acid are encountered)

Assorted rubber stoppers to fit above tubing

Hand-operated, intrinsically safe vacuum pump

Chemically resistant tubing 5/16" inside diameter; Teflon recommended

Wax pencils

Masking tape

Indelible ink pen

250-ml Erlenmeyer filtering flask with #6 one-hole stopper

500-ml Erlenmeyer flask with solid stopper

3-way Teflon valve

2-hole stopper fixed with short lengths of glass tubing (1 90^{o} elbow) to fit neck of sample bottle. Used as low cost substitute for filtering flask and eliminates need for transferring hazardous material to the sample container

Assorted lengths and diameters of wooden doweling or corner molding

Plastic sandwich bags (self-sealing bags not recommended in this case) and elastic bands

Disposable wooden "toaster" or "photographer" tongs

Disposable scoops, polyethylene, or stainless for solid materials

Litmus paper or pH range paper to use in waste characterization

Brass deflagrating spoon

Hand auger

Shovel

Stainless steel bailers with steel wire or monofilament line

Sample tags

Field log book

Chain-of-custody forms

Camera/film

Plastic containers/decontamination solutions for decontaminating outside of sample containers

Sample packaging and shipping equipment

---

(1) Open or closed containers including drums, abandoned tank trucks, railroad tank cars, buried or aboveground storage tanks;

(2) Surface impoundments such as ponds, pits, or lagoons which have received direct bulk discharges of concentrated wastes;

(3) Piles of concentrated sludges or contaminated soil;

(4) Soil near leaking drums, tanks, or direct discharges;

(5) Leachate breakouts; and

(6) Monitoring wells known to be located immediately adjacent to buried wastes.

Additionally, if the presence of a highly toxic substance has been confirmed on site, samples which would routinely be treated as environmental samples might have to be considered hazardous.

Sampling of containers (Item 1 above), especially drums, is one of the more frequently requested tasks at uncontrolled hazardous substance sites. Therefore, Section 10.2.4 provides a more detailed discussion of such sampling. The approach to sampling from the other locations listed is more briefly outlined in subsequent sections.

10.2.4 On-Site Containers

Containers at a hazardous site, typically steel drums, may have to be sampled to provide analytical data for initial site characterization and the preparation of legal cases. As the work at a particular site progresses, further sampling may be required as part of a site cleanup effort. The containers chosen for sampling may be opened or closed. A container opening plan and a work plan should be developed before sampling from closed containers takes place. The site safety plan for sampling from closed containers must be approved by the E&E Corporate Safety Director before such operations are conducted. Cleanup activities may require that all containers be sampled and analyzed prior to ultimate treatment or disposal, whereas legal case preparation will require the sampling of fewer containers.

The selection of containers to be sampled is based on a variety of factors including accessibility, background information and container conditions. The following is an outline of an approach to prepare for sampling from containers. For purposes of example, the outline is specific for drums. Methodologies for actually obtaining samples from other types of containers are addressed in Section 10.3.

Container Inventory. If possible, an initial inventory of containers should be made from off-site using observation, aerial photography, or remote sensing techniques. The purpose is to determine the effort needed to conduct the sampling as well as the hazards that may be expected on site.

An on-site inventory is then made to determine the number and condition of the drums, to further establish the conditions of the site and to record drum markings or any other information that might assist the investigation team. Each drum selected for sampling will be given a sampling number that will be marked on the container by spray painting, tagging or other means. A complete photo record of the drums' condition will be obtained. Drums in poor condition will not be selected for legal cases.

Sample Selection Criteria. As previously mentioned, a site cleanup operation usually requires opening and sampling each drum. For evidentiary purposes, however, it is usually necessary to open and obtain samples from relatively few drums. The number selected will be determined by factors such as total number of drums on the site, analytical constraints, background information, community sensitivity, etc. In many cases, the drums are scattered randomly over the site.

The initial step before sampling is to exhaust all sources of background information on the drum contents. If reliable information exists, the selection of one or more drums for sampling may be based on this information and confirmed by subsequent sample analysis.

In the absence of reliable information about drum contents, a random sampling approach may be employed. The first step is to identify the total number of drums readily accessible for opening and sampling. This would include those drums which present no problem in set up of the remote opening device, which require no movement prior to opening, and whose locations pose no threat to the safety of the team.

For example, on a site containing 10,000 randomly placed drums, many will be physically inaccessible, i.e., in the center of a large group or stacked on other drums. A simple random sampling scheme can be used to determine which of the accessible drums to sample. Each drum can be assigned a consecutive number, and a random number table can be used to choose those drums to be opened and sampled.

For example, assume the total available number of drums for opening and sampling is 100 and five samples are desired. Number the drums consecutively from 00 to 99. Choose any number on the table as a starting point and move in any predetermined direction in the table and select a number at any predetermined interval until five numbers have been selected.

10.2.5 Shipping Hazardous Materials

All hazardous materials are shipped using procedures described in Chapter 14. Medium concentration samples can be sent to the contract labs for analysis; high concentration samples are currently sent to the contract lab using Special Analytical Services. The High Hazard program is currently under revision and will eventually be incorporated into the IFB program.

10.3 HAZARDOUS SUBSTANCE SAMPLING TECHNIQUES

10.3.1 General Considerations. The majority of hazardous substance samples are grab samples. Occasionally, it is necessary to sample a multi-phase liquid medium, which will require either sampling each phase or obtaining a representative multi-phase sample, depending upon the objective of the sampling.

In general, the avoidance of contact with the contaminant is of utmost importance. Even though protective clothing and equipment are used by sampling personnel, it is prudent to use only those sampling techniques which minimize the risk of exposure. Sampling personnel should not kneel, sit, run (except to evacuate in an emergency), lean upon containers or walk through puddles.

Some general preparations should be made for obtaining samples of hazardous substances:

- A work plan should be developed prior to sampling (See Chapter 2);

- Sample containers should be prepared by temporarily marking the designated sample number on the container using a wax pencil. Pre-attached sample tags are not recommended because they interfere with the sampling operation and may become contaminated. The sample tags can be affixed following container decontamination;

- Following temporary marking, a small plastic bag is placed around the container and secured at the bottle neck with a rubber band. This minimizes the contact of contaminants with the outside of the container. Following the sample collection, the bag is removed and dropped in either the container from which the sample was collected or a proper disposal container.

- Provisions should always be made for personal equipment and sample container decontamination.

- Following decontamination, the sample containers are tagged and logged on the chain-of-custody record;

- Preparation should be made for the transport of containers and equipment. If Level A personal protection is being used, the number of samples which can be obtained between respirator air tank changes may be limited. A wheelbarrow or cardboard box can be used to transport equipment. Cardboard mailing tubes taped at one end can be used to hold glass tubing.

- If manpower permits, a third member of the sampling party can be utilized to transfer containers and samples to and from the hot line.

10.3.2 Sampling Techniques For Containers

The sampling method is determined by the type of container, access to the container (opened/closed), and the physical state of the material in the container (solid, liquid, or sludge). All container opening and sampling is conducted according to the E&E guidance manual for container opening and the E&E SOP on container opening procedures. Only specially trained peronnnel will conduct sampling involving drum opening.

Steel Drum

Access to the contents of a sealed drum will be accomplished by the remote opening method, preferably through the top of the drum. (See drum opening guidance manual and SOP.)

1. Liquid Waste.

One member of the sampling team carefully inserts a four-foot length of glass tubing through the drum opening. If possible, the tubing should be inserted at an angle to help obtain a representative sample. For sampling most liquids, a piece of tubing with an inside diameter of 6 to 8 mm is adequate. However, a larger bore tube may be needed for more viscous materials. The top end of the tubing is then blocked with a thumb or rubber stopper, and the tubing is raised from the drum to transfer the contents to the sample container. The sample container should be held in a convenient place by the second sampling party member. Releasing the thumb or rubber stopper allows the contents to empty into the container. The operation is repeated until an adequate volume is obtained.

Both members of the sampling party must try to avoid contact with the material on the outside of the tubing. Disposable wooden "toaster tongs" can be used to guide the contaminated part of the tubing to the container. When sufficient volume is obtained, the tubing is broken and discarded inside the drum.

Following are several important notes on sampling liquid wastes from containers:

- A ten percent ullage (head space) for expansion should be left in any container used;

- Sampling personnel must avoid allowing the material spilled on gloves during the sampling process to come in contact with the material from a subsequent drum. Potentially dangerous synergistic reactions may occur, resulting in failure of the protective clothing. Where the presence of incompatible materials is suspected, the sampler may put several disposable gloves over the hand (outside of the butyl rubber suit for Level A) which comes in contact with the material. The outer glove can be disposed of after each sampling operation.

- A rubber pipet bulb may be used on the sampling tube. Care must be taken to prevent the material from contacting the bulb.

- The sampling team should attempt to determine if multi-phase liquid layers are present in the drum by observing the contents of the glass tubing;

- If the sampling party sees any evidence of a reaction (light, smoke, etc.), they will immediately abandon all equipment and evacuate the site; and

- If the glass tubing becomes clouded or smokey when it is inserted in the drum, it should be withdrawn and discarded since this indicates the presence of caustics or hydrofluoric acid. A length of rigid plastic tubing and a plastic sample container should be substituted.

2. Sludge Waste. For sludges, a larger-bore glass tubing or a 40 ml VOA (volatile organics analysis) vial fastened to a length of wooden dowel may be used. A minimum of 20 to 30 grams of concentrated sludge is required for extraction and preparation. This 20 to 30 grams would be approximately equivalent to a 40 ml VOA vial three-quarters full. A wax pencil can be used to mark a line on the outside of the sample bottle. The sampling apparatus may be discarded with other waste accumulated during the sampling operation.

3. Solid Waste. Occasionally, a drum containing solid or granular waste may be encountered. This type of material is often contained in fiberboard drums. A disposable non-sparking scoop may be used for an open-top drum, while a brass deflagrating spoon attached to a length of wooden dowel may be used to obtain material through a bung hole. Only 20 to 30 grams of this type of material are required.

Following are important notes on sampling sludges and solids from containers:

- It is possible that when a glass tube is inserted through a hole in a drum a solid layer may be encountered below the liquid layer. If the solid layer is soft, it is probably a sludge, and the sample may be obtained using the method described previously. If the solid is hard, it could be a hardened sludge, or it may be an exotic, active metal such as sodium. A suggested sampling method would be to put pressure on a length of glass tubing carefully to obtain a small core for analysis. A stainless steel micro spatula could be used to remove the material from the end of the tubing. Care should be taken to keep the material from contacting water. It should also be noted whether the material discolors upon contact with air;

- The use of a sampling trier or slotted sampler is not recommended for obtaining a granular solid sample, as the friction and/or percussion associated with that action could cause an explosion.

Tanks, Tank Trucks or Tank Cars

There is an additional risk in sampling these types of containers because it may be necessary to climb on them te gain access to the opening. It is assumed that these containers have liquid rather than solid wastes.

1. Hand Vacuum Pump Method. A 250-ml Erlenmeyer side-arm flask is fitted with a #6 one-hole rubber stopper. A 10-cm piece of glass tubing is inserted through the hole of the stopper. A short length of Teflon tubing is used to attach the glass tubing to the pump (5/16" I.D. tubing will fit). A length of Teflon tubing sufficient to reach the desired sampling depth inside the tank is attached to the side arm of the flask. The tubing is then lowered to the desired level inside the tank. See Figure 10-1.

A long wooden dowel or corner molding may be attached to the tubing, which has a tendency to coil itself. Teflon tubing is recommended because it is more chemically resistant than Tygon. (The tubing used should be new, as should be the doweling or corner

3. Multi-phase Sampling. Tanks or tank cars may contain liquid material in two or more phases or layers. This can be determined by using either of the methods described above. The sample tubing is lowered to various depths in the tank, and the appearance of material obtained in the flask and the approximate depth are noted. The tubing or supporting wooden doweling may be graduated to provide a quick depth indication, so that samples of each layer can be obtained by lowering the tubing to the previously noted depth.

4. Bailing. In the event that a tank, tank truck or tank car is too deep for use of vacuum methods or if the material is viscous, bailing may be required. A standard well bailer may be used. Care must be taken in the transfer of the sample to the sample bottle. The bailer must be thoroughly decontaminated following each use. It is advisable to commit this bailer to concentrated samples only and not use it for water samples.

5. Opening Drain Valves. Although it is relatively easy to open the drain valve of a tank to obtain a sample, there are inherent problems, such as the failure of the valve to close and the presence of an organic layer of material on top of a water layer which would come out first from a bottom drain valve. Opening drain valves is not a recommended procedure.

10.3.3 Surface Impoundments

The sampling approach for on-site surface impoundments thought to contain high concentrations of hazardous material is dependent upon such factors as the surface area, depth, and stratification of layers of the impoundment. Following are guidelines for taking such samples.

- Several samples should be taken from different points in the impoundment;

molding it could be argued that wood might introduce contaminants to the sample or reduce concentration through adsorption; however, since these methods are suggested for concentrated materials, it is unlikely that this would greatly affect the results of any analysis.)

The sampler then operates the pump to draw a vacuum on the flask, causing the liquid to enter the flask. When sufficient sample volume is obtained, the material is then transferred to the sample container. The tubing, flask and rubber stopper are placed in an appropriate disposal container. If the sampler notices condensed vapors collecting in the pump line above the sampling container, depending upon the type of pump being used, the pump may need decontamination before collecting the next sample. In any case, the pump should be flushed with air between samplings.

As an alternative, an eight-ounce sample bottle fitted with a rubber stopped, as described in Table 10-1, may be substituted for the side-arm flask. This eliminates the need to transfer the material from the flask to a sample bottle; however, it requires more advance time to prepare the stoppers and glass bends. See Figure 10-1.

Although this method will work for most tanks, it is limited to a total depth of about 16 to 20 feet, which should be more than adequate for most tank trailers.

2. Evacuated Flask Method. A 500-ml Erlenmeyer side-arm flask is fitted with a solid rubber stopper (Figure 10-2). A short piece of Tygon tubing is attached to the side-arm. In a laboratory, a vacuum is drawn on the flask and the Tygon tubing is sealed with a screw clamp. The evacuated flask, along with a sufficient length of Teflon tubing and a Teflon valve, is attached in-line to the Teflon tubing on the side-arm, and the length of Teflon tubing is attached to the free end of the Teflon valve. The Teflon tubing is lowered to the desired sampling depth, the screw clamp is opened, followed by the Teflon valve, and the sample enters the flask. The contents are transferred to the appropriate sample container, and the tubing, flask and valve placed in appropriate disposal container.

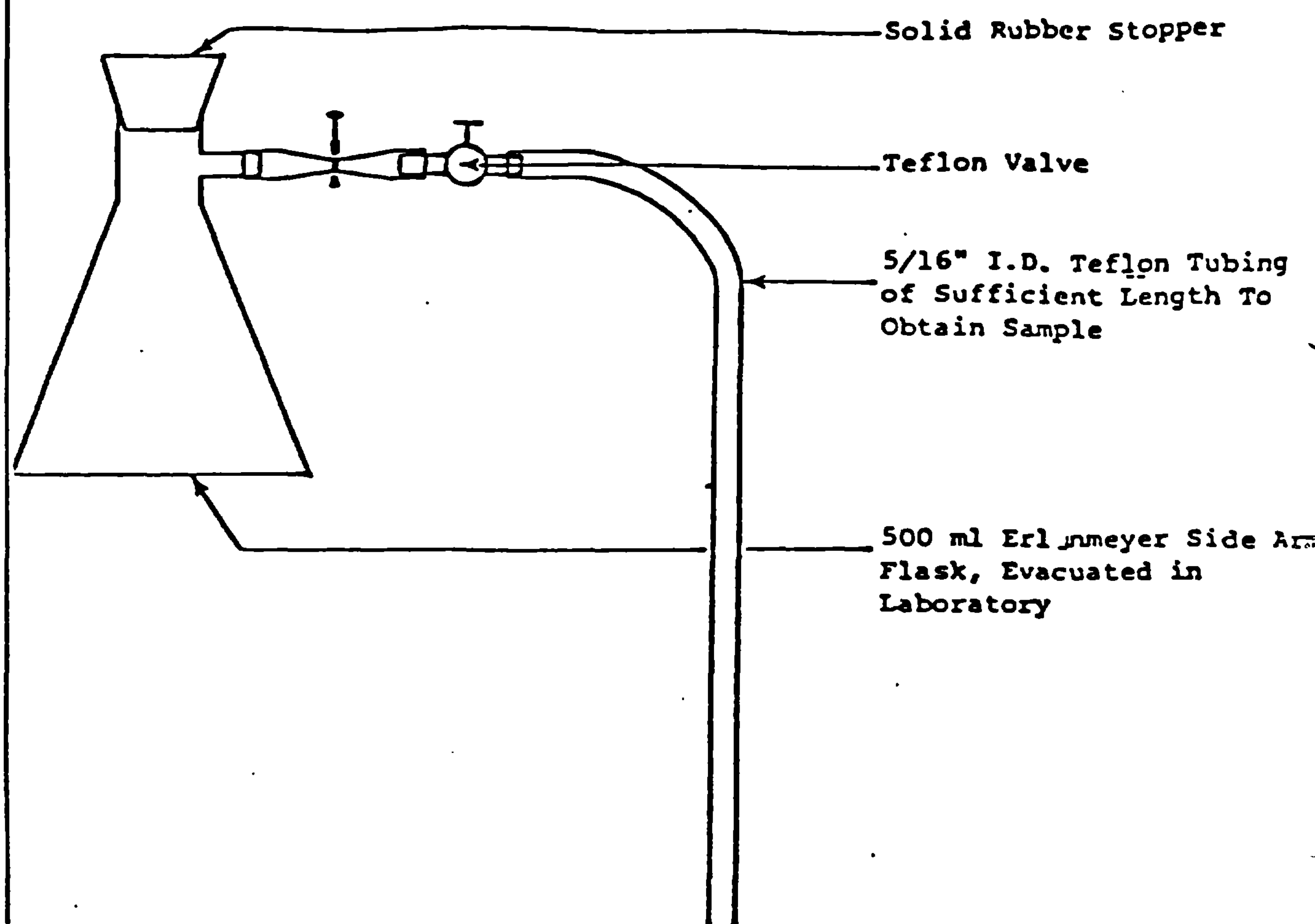


FIGURE 10-1 EVACUATED FLASK

- o If the impoundment is large, the surface area may be divided into grids and a sample taken from each grid or from a predetermined number of randomly chosen grids;

- o The safest technique for obtaining samples is to use a Teflon beaker or 8 oz. glass jar attached to the end of a telescoping aluminum pole by a clamp. The sample medium is transferred from the Teflon beaker or jar to an eight-ounce wide-mouth glass jar (10 percent ullage is left). The apparatus must be thoroughly decontaminated between samples;

- o Obtaining samples from different depths requires some ingenuity. It is not recommended that a boat be used, which would allow the obtaining of multi-level samples with a weighted bottle sampler. Instead, it is possible to suspend a nylon line across the impoundment and attach a length of Teflon tubing to a graduated wooden dowel, which in turn is attached to the nylon line in such a way that the dowel can be lowered to different depths. A portable, intrinsically safe vacuum pump can then be used to draw samples into containers as the dowel is lowered to different depths; and

- o Obtaining a sludge sample from the bottom of an impoundment is limited by the use of the pole/Teflon beaker, which may be employed from the bank to scoop sludge from the bottom.

10.3.4 Sampling From Waste Piles

Waste piles may consist of sludges from various processes or contaminated soil excavated during site cleanup operations. The sampling approach is dependent on the size or volume of the pile, known or suspected waste constituents, and other physical factors such as the density of the pile, presence of other material such as crushed steel drums, or soil type. Following are guidelines for sampling a waste pile.

- If the pile is small, the surface area can be divided into a number of grids corresponding to the number of samples to be taken and a surface sample taken from each grid using a stainless steel scoop. An eight-ounce wide-mouth glass jar three quarters full is a sufficient in most cases.

- If the pile is large, the surface area may be divided into a number of grids and a sample obtained from each grid by combining a quantity of material from several locations within the grid.

- If subsurface samples are desired, a shovel or hand auger may be used to dig or bore into the pile. Extreme caution is urged in undertaking any subsurface sampling because of the potential for encountering buried containers or sparking metal objects in the pile. A metal detector survey of the pile may be advisable prior to sampling.

- The use of slotted sampling triers or hand augers to obtain core samples will be limited by the soil/sludge characteristics.

10.3.5 Sampling Soil

Soil saturated by direct leaks or discharges may contain high concentrations of contaminants, depending upon the amount of weathering to which the soil has been exposed and the physical/chemical characteristics of the contaminants.

- If the soil appears to be stained from one source such as an obviously leaking tank or drum, the sample may be obtained by using a stainless steel scoop; and

- If the soil is stained over a large area, it may be necessary to employ a grid sampling system, as described in Section 10.3.3. It may also be advisable to obtain surface and subsurface samples. Again, caution is urged if subsurface samples are to be obtained.

10.3.6 Sampling Leachate

One of the principal pathways of off-site movement of contaminants is leachate from buried wastes. Because leachate streams potentially contain high concentrations of contaminants, it is recommended that samples of leachate be handled and treated as hazardous substance samples until sufficient reliable data indicates otherwise.

- o The ideal situation is to sample leachate streams under both low and high flow conditions for an adequate data base.

- o The sample container is used as the sample obtaining device, as leachate stream samples will be grab samples. Unless prior arrangements have been made with the analytical laboratory, the container of choice will be an eight-ounce wide-mouth glass jar, with a ten percent ullage left.

- o If the leachate stream flow is low, a shovel may be used to dig a small hole at the sampling point. The hole is allowed to fill with leachate, and sufficient sample volume is then obtained. The shovel should be decontaminated after use.

10.3.7 Sampling Monitoring Wells

Occasionally, a groundwater monitoring well may be installed where high concentrations of contaminants may be present, in some instances up to 100% concentration. Should this situation be suspected, the sample may be obtained by using a stainless steel bailer.

Unlike the sampling of monitoring wells for routine groundwater/environmental samples, purging of static material is not recommended because of the risk of exposure and subsequent waste disposal problems. Care should be taken when transferring the bailer contents to the sample container.

CHAPTER 11
EQUIPMENT DECONTAMINATION PROCEDURES

11.1 EQUIPMENT CLEANING PROCEDURES IN THE FIELD

Sampling equipment should be cleaned between sampling locations using the following steps.

- o Initially rinse item with tap water (from orchard sprayer or squirt bottle) to remove gross contamination.

- o Clean item by washing with Alconox detergent and tap water. A brush may be used to dislodge sediments. Personnel should be aware of the materials which they are handling and use special decon solutions for cleaning when warranted. No solvents are to be used on equipment which is constructed of butyl rubber and/or Neoprene components.

- o Rinse with tap water (using brusher if necessary), and shake off excess water.

- o Triple rinse with a pesticide grade acetone or ACS grade methanol to remove organics. After final organic solvent rinse, allow all acetone or methanol to evaporate completely before continuing.

- o Triple rinse thoroughly with distilled water. Shake off excess water.

- o Wrap the sampling equipment with aluminum foil once decontamination is completed to prevent accidental contamination of the sampling equipment.

The organic solvent rinse can be omitted for equipment that does not come into direct contact with sampled material or contaminants or if there is no possibility onsite of organic contamination. Generally, the plastic (Lucite R) filtering apparatus is not rinsed with acetone, unless it is severely contaminated by oils or organic film. Acetone may degrade the plastic.

11.2 EQUIPMENT CLEANING PROCEDURES FOR STORAGE

All non-disposable equipment should be cleaned in the field before being returned to the warehouse for storage. During severe winter conditions, it may be necessary to repeat the final rinse step in warmer warehouse conditions. The following procedures are used to clean equipment prior to storage:

- o After using equipment, rinse with water in the field, and wipe with paper towel;
- o Wash thoroughly with warm water and phosphate-free laboratory detergent, using a bottle brush to remove particulate matter and surface film;
- o Rinse thoroughly with warm tap water;
- o Rinse thoroughly with distilled water (at least 3 times);
- o Rinse thoroughly with acetone (pesticide grade) or methanol, allow to air dry. Rinse with distilled water at least 3 times;
- o Wrap with aluminum foil.

All ice chest and reusable shipping containers are washed with a mild detergent (interior and exterior) and rinsed with tap water and air-dried before storage.

Vehicles should be washed (if possible) at the conclusion of each field trip. This routine maintenance should minimize any chance of further contamination of equipment or samples. When vehicles are used in conjunction with hazardous waste site inspections, or on studies where pesticides, herbicides, organic materials or other toxic matter known or suspected to be present, a thorough interior and exterior cleaning is mandatory at the conclusion of such investigation.

11.3 SPECIAL DECONTAMINATION PROCEDURES AFTER SAMPLING OILY MATRICES

Oily contamination requires a stronger detergent than Alconox or Liquinox. If the material that has been sampled is a sludge or a particularly resistant heavy oil, rinse the equipment first with acetone. Then, wash the equipment in a strong solution of trisodium phosphate (TSP) and follow up with normal decontamination procedures. Do not bring field analytical equipment into contact with oily materials.

Sampling for dioxin calls for a specialized decontaminations procedure employing ethanol and trichloroethane. Refer to Chapter 12 for these specialized procedures.

CHAPTER 12
SAMPLING FOR DIOXIN

Sampling for dioxin may be required at potentially contaminated sites. Field procedures for the investigation of dioxin sites are considerably different from those for other types of hazardous waste sites. Dioxins, particularly 2,3,7,8 - TCDD, are highly toxic and can pose health hazards to humans, even at very low levels of exposure. Hence, safety considerations are of utmost importance on dioxin sites. Decontamination procedures differ considerably from the standard procedures presented in Chapter 11. Sample handling procedures also differ from procedures for most other types of samples. Even documentation requirements for dioxin samples are different. The Sample Management Office (SMO) has produced a special CLP Dioxin Shipment Record (Appendix 12-A) which replaces the traffic reports.

A complete guide to all procedures related to dioxin sampling, handling, and documentation requirements is beyond the scope of this SOP and would be redundant to work already done on this subject. For an in-depth explanation of dioxin sampling techniques, as well as documentation, handling, and shipping procedures, the reader is referred to the:

SAMPLING GUIDANCE MANUAL FOR THE NATIONAL DIOXIN STUDY
(U.S. Environmental Protection Agency Office of Water Regulations and Standards Monitoring and Data Support Division).

All Region V FIT dioxin sampling handling and safety provisions will be conducted in conformance with this document and other CLP guidelines as published in "Users Guide to the Contract Laboratory Program", (EPA Document, revised July 1984), and technical memorandum regarding dioxin performace evaluations on samples analyzed through the Contract Laboratory Program.

USEPA Contract Laboratory Program
Sample Management Office
P.O. Box 818   Alexandria, Virginia 22313
FTS 8-557-2490   703/557-2490

CASE NO:	BATCH NO:

CLP DIOXIN SHIPMENT RECORD

Name:	Sampling Office:	Ship To:	
City & State:	City & State:		
EPA Site No:	Sampling Contact: (name)	Date Shipped:	
Latitude:	Sampling Date:		
Longitude:	Data Turnaround:		
Tier: 1 2 3 4 5 6 7 (circle one)	15-Day ____ 30-Day ____		

	MATRIX		DESCRIPTION						ADD'L ANALYSIS	
SAMPLE NUMBERS	SOIL/ SEDIMENT	OTHER:	FIELD SAMPLE	SAMPLE TO DUPLICATE	SAMPLE TO SPIKE	BLANK	EQUIPMENT RINSATE	OTHER: (SAS ONLY)	SPECIFY: (SAS ONLY)	

WHITE—SMO Copy   YELLOW—Region Copy   PINK—Lab Copy for Return to SMO   GOLD—Lab Copy

CHAPTER 13

CONTROL OF CONTAMINATED MATERIALS

13.1 INTRODUCTION

For the purposes of this chapter, "contaminated materials" are defined as any byproducts of site investigation that are suspected or known to be contaminated with hazardous substances. These byproducts include:

- decontamination solutions
- disposable equipment
- drill cuttings
- drilling muds
- well-development fluids
- spill-contaminated materials
- water bailed from wells during sampling

Hazardous wastes generated during investigations will require compliance with the requirements of the Resource Conservation and Recovery Act (Public Law 94-580) for generation, storage, transportation, or disposal. In addition, there may be state regulations that govern the disposal action. Questions which arise about individual state requirements for disposal of contaminated byproducts of the site investigation may be answered by contacting the following state agencies:

ILLINOIS

Division of Land and Noise
Pollution Control
Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62706

(217) 782-6760

INDIANA

Land Pollution Control Division
State Board of Health
1330 West Michigan St.
Indianapolis, Indiana 46206

(317) 633-0194

MICHIGAN
Office of Hazardous Waste Management
Environmental Services Division
Department of Natural Resources
Box 30028
Lansing, Michigan 48909

(517) 373-2730

MINNESOTA
Solid and Hazardous Waste Division
Pollution Control Agency
1935 West County Road, B-2
Roseville, Minnesota 55113-2784

(612) 297-2735

OHIO
Office of Land Pollution Control
Environmental Protection Agency
P. O. Box 1049
Columbus, Ohio 43216

(614) 466-8934

WISCONSIN
Hazardous Waste Section
Wisconsin Dept. of Natural Resources
P.O. Box 7921
Madison, Wisconsin 53707

(608) 266-2111

The work plan for a site investigation must include a description of control procedures for contaminated materials. This description should estimate the amounts of contaminated materials that may be produced, describe containment equipment and procedures and propose disposal or storage methods. As a general policy, the site investigation should employ methods that minimize the generation of contaminated spoils. Handling and disposing of potentially hazardous materials can be expensive and time consuming. A containment method should be selected that is consistent with RCRA, that does not increase the real hazard associated with the site and that is the most practical available alternative.

13.2 SOURCES OF CONTAMINATED MATERIALS AND SCREENING METHODS

Contaminated materials may be produced and exposed to the environment as a result of sampling activities. The following materials, which may be derived during the course of a site investigation, must be managed and disposed of properly during and after sampling:

- suspected hazardous materials,
- drilling spoils (soils, muds, boring and cutting materials)
- excavation spoils (trenched or hand-dug),
- water from monitoring well development,
- fluids and sediments resulting from decontamination of equipment and personnel,
- disposable equipment, tools and supplies,
- water from hydrologic testing and
- materials contaminated by accidental spills.

When the investigation is being conducted on-site in the vicinity of a contaminant release, the best policy is to assume that some of the investigation derived materials are contaminated and will need to be handled as hazardous waste. Generally, soils, spoils, water, fluids and sediments generated during a site investigation are suitable for disposal onsite. Similarly, disposables can generally be disposed of with general refuse. Screening methods may help to determine the hazardous nature of the materials. Screening visually or with either the HNu or OVA may be useful in evaluating the presence of organic contaminants. Visual screening involves looking for unnatural coloring or the presence of oily or asphaltic layers in soils and oily sheens or turbidity in water. The HNu and OVA are capable of screening only for the presence of volatile organic compounds. Screening provides an indication of the degree of contamination, and therefore an indication of the level of containment necessary.

13.3 CONTAINMENT PROCEDURES

In absence of specific guidelines to the contrary by EPA or local state agencies, FIT personnel will use procedures set forth in <u>E&E Standard Operating Procedures For Management and Disposal of Contaminated Spoils from Field Inspections or Investigations</u> (in draft), attached as Appendix 13-A. Team leaders should be fully aware of its contents and of the alternative methods for disposal. In particular, Section III-D.1 describes management options for containment of drilling and excavation spoils. Because much activity in

Region V involves drilling and installation of ground water monitoring wells, FIT must consider containment options in its drilling/work plans. Prior to execution of the site work, the team leader should consider the potential for exposing contaminated materials and estimate the volume of material as best as possible. The selected procedure should be checked to assure that it meets with RCRA and the proposed containment procedure should be discussed with the USEPA Project Officer and with the state environmental agency. A USEPA memorandum regarding the disposal of waste materials and the use of subcontractors for waste disposal is attached as Appendix 13-B.

In general, the quantity of material derived at a site during drilling of an individual well will be relatively small. Slip trenching, burial, or surface disposal may be an appropriate action. Other options may include placement in an on-site lagoon or deferring responsibility to the site management (See Appendix 13-A). If the materials contain high concentrations of contaminants or contain highly toxic substances such as dioxin, drumming may be the only available alternative for containment. Additionally, the state regulatory agency may require all materials to be drummed. Under such circumstances, the team leader must make arrangements for drum delivery, pick up and transport of the <u>hazardous materials</u> to a RCRA and CERCLA approved disposal facility or to a secure, approved storage area. On-site storage in a secured location is generally the preferred storage mechanism.

APPENDIX 13-A

STANDARD OPERATING PROCEDURES

FOR

Management and Disposal of Contamianted Spoils Derived from

Field Inspections or Investigations.

(Draft)

STANDARD OPERATING PROCEDURES (SOP)
FOR
MANAGEMENT AND DISPOSAL OF CONTAMINATED SPOILS
DERIVED FROM FIELD INSPECTIONS OR INVESTIGATIONS

I. PURPOSE

To establish policy, assign responsiblity and setforth procedures for the management and disposal of contaminated spoils generated by FIT inspection and investigation activities.

II. SCOPE

The provisions of this SOP apply to all Ecology and Environment FIT personnel and its subcontractors engaged in the field investigation of uncontrolled hazardous waste sites under EPA Contract No.

III. POLICIES

A. The paramount objective in managing spoils generated by field inspections/investigations is to minimize the insult to the environment or risk to the public health.

B. Field inspections/investigations will be planned and conducted to insure that the existing contamination and pollutant migration are not increased because of required field activities.

C. All FIT personnel will become familiar with this SOP and conduct field operations in accordance with its provisions.

D. All subcontract personnel will be advised of this SOP and their field activities will be monitored and supervised by FIT project leaders to insure they comply with its provisions.

E. Disposal of spoils generated by field inspection/investigations will be in accordance with local, state, and federal solid waste waste guidelines. The spirit and intent of RCRA will not be violated.

F. If onsite conditions dictate, the planned method of disposal (for spoils generated) can be changed by the project team leader to accommodate local situations. However, any deviations require that final disposal of any hazardous spoils be accomplished in a responsible manner and comply with the intent of this SOP.

G. A Contaminated Spoils Management Disposal Plan will be included in the Site Safety Plan. If deviations to this plan are required by local conditions, such changes will be recorded and reported to the NPO on return from the field.

IV. RESPONSIBILITIES

A. The National Project Manager (NPM) is responsible for:

1. Insuring that FIT activities are conducted in compliance with the provisions of this SOP.

2. Assigning an individual in the NPM Office to perform audits of regional spoils management and disposal practices.

B. The FIT Leader is responsible for:

1. Developing a contaminated spoils management and disposal plan for each site inspection/investigation where materials are expected to be generated as a result of field activities.
2. Monitoring activities of project team leaders to insure compliance with this SOP.

3. Assigning an approval authority at the regional level to review all site material management and disposal plans.

C. Each Project Team Leader is responsible for:

1. Complying with the provisions of this SOP.

2. Developing the spoils management and disposal plan for the project he/she has been assigned responsibility for.

3. Coordinating disposal procedures with subcontractors, if required.

4. Managing field activities to insure that the spoils management and disposal methods are accomplished according to the plan.

5. Where deviations from the management and disposal plan occur, insuring that the alternative minimizes insult to the environment and human health.

D. FIT Members are responsible for:

1. Complying with the contaminated spoils management and disposal procedures defined in the site plan.

2. Assisting the site Project Team Leader in analyzing alternative management and disposal practices where needed.

V. PROCEDURES

A. "Materials Derived" From Field Activities

a. Define the types and estimated quantity of the materials.

b. Review the intended work plan and develop a rational means for handling accumulated materials from the investigation.

c. Develop the management and disposal options.

d. Prepare and obtain approval for the site-specific management and disposal plan as part of the site safety plan. The approval must come from the DPO and/or the site owner, or local government official as appropriate.

e. Inform potential subcontractors of the provisions of the plan covering their specific contract requirements (if subcontracts are involved).

3. *Execution of the Management and Disposal Plan:*

a. Use field monitoring instruments and visual appraisal to survey spoils derived from the investigation.

b. Follow the management procedures outlined in your site specific plan and document them in the field notes.

c. Coordinate any deviations from the plan and document them in field notes.

d. Document any storage of suspected hazardous materials.

C. Disposal Strategy

In the decision process to select an optimum disposal alternative, the Project Officer must consider the anticipated concentration of the contaminant and hazarous nature and the legal and safety constraints imposed by the site owner, the state or federal agencies. The proximity to sensitive environments and to the public at large are also important considerations.

The following section gives a summary of disposal options, according to class of spoils, that should be considered. The management and disposal plan must specify the option selected and state a brief rationale for its selection. Regardless of option selected, approval from the owner, state, and/or EPA, as appropriate, must be secured.

D. Spoil Classes and Management Options

1. Drilling and Excavation Spoils (See section V, A, 4 above)
Management Instructions for Drilling and Excavation Spoils

1. Contaminated spoils may be derived/generated from field inspections or investigations. For the purspose of this SOP, the generic term "field activity" will be used to collectively refer to all field activities conducted "on site" or "off site."

2. No distinction is made regarding the pure definition of "on-site," "off-site." Again, for the purpose of managing generated spoils, it matters little whether it is generated (technically) on or off site. The main requirements are to identify the site owner and determine if the spoils are concentrated or not.

3. The overriding premise on which this SOP is based is that the FIT will do nothing to increase the real hazard associated with the site. All materials disposal planning will be geared to minimum insult to the environment or human health. Accordingly, the preferred strategy is to leave the generated material in the location from which it was derived. The most important task becomes securing approval to implement this strategy.

4. Spoils that may be derived/generated as a result of field activities include but are not limited to the following:

   o Drill spoils: Soils, muds or boring material, auger cuttings, excess material from split-spoon sampling, excavated soils, bailing water, well development wastes

   o Expendable contaminated equipment

   o Decontamination liquids

B. Elements of the Management and Disposal Plan

The development and execution of the management and disposal plan involves three phases:

1. Determination of Site Conditions from Preliminary Assessment and Site Inspection:

   a. Determine general areas for the conduct of proposed field activities.
   b. Identify property boundaries and offsite public and private properties. Establish ownership for the area of operation (i.e. area you will be working in). Classify study areas into concentrated and non-concentrated zones.

2. Development of the Site-Specific Management and Disposal Plan:

a. Concentrated Form -This includes all spoils suspected to be highly contaminated because they were obtained from known or suspeced waste burial or land surface disposal zones. All such spoils should be contained. The options for management, listed in order of preference, are:

- o Replace in original location - Spoils should be placed back into well, or bored or excavated area from which they were obtained.

- o Place in existing onsite lagoon that contains hazardous wastes - This option depends on availability of lagoon and requires a judgment decision. The team leader should not knowingly increase the pollution potential of the lagoon by adding quantities that cause it to overflow, or by introducing hazardous materials more concentrated or of significantly different chemical or hazardous properties from the lagoon's existing contents.

- o Defer to party responsible for site management - The responsible party might include the owner or manager or a government official.

- o Dispose in approved hazardous waste facility - This is the least preferable disposal alternative because it requires additional time and money.

b. Non-Concentrated Form - This class of spoils is associated with sampling of hazardous substances that have migrated from disposal locations in ground or surface water. It includes all types of environmental sampling FIT performs, i.e. groundwater, surface water, and soil and sediment sampling. Such sampling involves diluted concentrations or pollutants generally in the parts per billion range. Investigation-derived spoils from environmental samples are also weakly contaminated and the short-term release of such contamination is generally insignificant in terms of environmental pollution. Unless infectious agents or toxins of remarkable potency (e.g. dioxin) are suspected, non-concentrated spoils do not require absolute containment and disposal. All such spoils must appear clean, natural, and uncontaminated, and not obtained directly from waste disposal zones. The management options are listed in order of descending preference:

(1) In cases where spoil quantities are small and easily containable, the spoils should be contained and replaced in original location:
- o Replace borings or soil cores into bore hole
- o Return water samples to well or surface water body
- o Replace excavated soils in original location

(2) In cases where large spoil quantities are involved:
- o Drill takings and drilling muds should be scattered around the drill hole and leveled.
- o Well-development water should be disposed on the land surface aroung the well
- o Well bailing water should be disposed on land surface around well

2. Disposable Equipment[1] (See section V, A, 4 above)

Management Instructions for disposable equipment

- o Place in 55-gallon (lid-type) drums and defer disposal to site management or responsible government authority.

- o Bury onsite in a location with existing soil contamination

- o Decontaminate and dispose in local sanitary landfill

3. Decontamination Liquids and Rinses (See section V, A, 4 above)

Management instructions for decontamination fluids and rinses.

a. Small quantities of decontamination liquids generated with decon of personnel and small sampling can be:

- o Emptied on site surface where soils are already contaminated.
- o Placed in existing hazardous waste lagoon on site (if available).
- o Placed in 55-gallon drums and deferred on site management for disposal.
- o Placed in 55-gallon drums and transported to approved hazardous waste facility.

b. Large quantities of decontamination liquids can be generated when large equipment is cleaned.

- o The large equipment (backhoes, drill rigs, etc.) should be decontaminated at an onsite location and the liquids allowed to seep into existing hazardous waste disposal areas.
- o Contain decon liquid and place in existing lagoon on-site.
- o Contain decon liquid and dispose of it in approved hazardous waste facility.

---

[1] Glass rods used in drum sampling should be broken and left in drum from which the sample was obtained.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DEC 13

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Disposal of Waste Materials Resulting from REM/FIT Activities

FROM: Russel H. Wyer, Director
Hazardous Site Control Division

TO: ESD Directors
Regional Air & Waste Division Directors
Zone I & II FIT Regional Project Officers

The issue of responsibility for "wastes" resulting from REM/FIT contractor field activities has become a problem of increasing concern for several Regions. These wastes may include drilling spoils, purged well water, decontamination fluids and disposable sampling equipment or clothing. In many instances, provided proper waste handling or containerizing practices are employed, waste materials resulting from REM/FIT activities can be left on site. However, the instances in which EPA must consider removal of wastes to a permitted hazardous waste facility is increasing.

The primary method at present for accomplishing the proper disposal of REM/FIT wastes is through subcontracting mechanisms within the REM/FIT contracts. Whenever it is necessary to containerize and remove wastes resulting from REM/FIT investigative activities, all RCRA requirements must be met. The REM/FIT contractors are responsible for subcontracting with reputable waste transporters and for assuring compliance with RCRA requirements.

Even through the REM/FIT contractors must provide for the disposal of wastes resulting from their field activities which are conducted in EPA's behalf, these wastes are considered, in fact, to be EPA wastes. Consequently, EPA must initiate the appropriate manifest documents for transportation and disposal. This approach is consistent with the position adopted by EPA when the REM/FIT contracts were being negotiated, prior to award.

In order to provide a timely process for disposing of REM/FIT field activity wastes, Regions are requested to do the following:

(1) Assist the REM/FIT contractors in obtaining EPA identification numbers;

(2) Sign the required manifests as generators; and

(3) Assist the contractors in identifying authorized, permitted facilities for proper treatment, storage and/or disposal of wastes.

The REM/FIT contractors will be responsible for subcontracting with creditable, responsible transporters. The Regions should also request in writing that the contractors dispose of the waste at a permitted facility. The Technical Directive Document (FIT) or Work Assignment (REM) should be used to document the request.

Please let me or my staff know, if you have any comment on this approach.

CHAPTER 14

SAMPLE HANDLING, PACKAGING AND SHIPPING PROCEDURES

14.1 GENERAL

After samples are collected, they must be handled in a manner which will ensure that their integrity is maintained. Procedures which are implemented to ensure accurate analytical results and the safety of samples during shipping and analysis are presented in this chapter.

14.1.1 Chain of Custody

Details about chain-of-custody procedures are presented in Chapter 15.

14.1.2 DOT Regulations For Shipping Preservatives

DOT and EPA have reached agreements concerning the shipment of environmental samples, particularly where preservatives such as nitric acid, which in concentrated form would fall under DOT Hazardous Material Regulations, are used in water samples. In a letter dated 11 April 1979, DOT indicated to the EPA that the following materials were exempt from Hazardous Materials Regulations:

- Hydrochloric acid solutions at concentrations of 0.04% by weight or less.

- Mercuric chloride in water solutions at concentrations of 0.004% by weight or less.

- Nitric acid in water solutions at concentrations of 0.15% by weight or less.

- Sulfuric acid in water solutions at concentrations of 0.35% by weight or less.

- Sodium hydroxide in water solutions at concentrations of 0.08% by weight or less.

- Phosphoric acid in water solutions at concentrations yielding a pH range between 4 and 2.

14.2 PACKAGING AND SHIPPING ENVIRONMENTAL SAMPLES (LOW CONCENTRATION)

14.2.1 Bottle and Preservative Requirements

See Chapter 5 for bottle selection and preservation requirements.

14.2.2 Paperwork

- Chain-of-custody

  Only one site may be listed on each form:
  White Copy - Shipped with samples.
  Pink Copy - Maintained in FIT files.
  Yellow Copy - Returned to office and then forwarded to CRL.

See Appendix 14-A for examples of completed form.

- Receipt for Split Samples

  A receipt should be given for samples split with property owners. A chain-of-custody form can be modified to serve as a receipt document or the receipt form shown in Appendix 14-A can be used.

- <u>Traffic Reports</u>

  Example of <u>Organic</u> and <u>Inorganic</u> Traffic Reports are shown in Appendix 14-A.

  White Copy - Mail to sample management office.
  Pink Copy - Retain in FIT file.
  All others - Ship with samples.

14.2.3 <u>Packaging and Shipping Procedures</u>

It is the responsibility of the shipper (person signing the shipping papers) to ensure that samples are packaged in accordance with the provisions of this SOP. All sample containers must be placed inside a strong outside shipping container. A sturdy metal picnic cooler lined with hard plastic inside is recommended. The following is an outline of the procedures to be followed.

- Using fiberglass tape, secure the drain plug at the bottom of the cooler to ensure that water from ice melting does not leak from the cooler.

- Line the bottom of the cooler with a 3" layer of cushioning/absorbent material such as vermiculite. Use a surgical mask when handling vermiculite, since that material has been found to contain asbestos.

- Check screw caps for tightness and mark sample volume level on the outside of all bottles with the exception of the VOA's. A wax pencil may be used for this. Secure bottle/container tops with strapping tape. Secure string from numbered EPA sample tag around neck of all sample containers with strapping tape, prepare an Avery label and secure it and the corresponding traffic report sticker to the bottle with clear plastic tape. Do not wrap any wire tags around the neck of the sample bottle. Doing so may introduce metal contamination. Place the sample inside a heavy duty plastic bag and seal the bag with strapping tape. Place sample containers in the cooler.

- Small containers, such as 40 ml septum vials for volatile organics analysis, must be placed in small plastic sandwich or whirltop bags. Vermiculite should be packed around the vials for protection. When shipping the vials with larger containers, steps should be taken to prevent the shifting of the larger containers which might break the smaller ones.

- Additional cushioning/absorbent material should be placed between the sample containers by filling all remaining space with vermiculite.

- Vermiculite cushioning is also required for plastic sample containers.

- Ice sealed in plastic bags should be placed in the cooler when samples must be cooled. Uncontained ice is not recommended because melting may leak to the outside.

- The documents accompanying the samples should be placed and sealed in a large plastic bag attached to the inside of cooler lid so that they will not be damaged by leaks.

- The lid of the cooler is closed and the latch fastened.

- Upon completion of the Federal Express airbill, wrap cooler with nylon strapping tape at two locations.

- Affix numbered orange EPA custody seals on front right and back left of cooler. Cover seals with wide clear tape.

- The following self-adhesive labels are placed on the outside of the cooler:

Name and address of receiving laboratory with return address.

Arrows indicating "This End Up" on all four sides.

"Fragile" on two sides.

Additional labels, such as "Liquid in Glass", are optional.

- o The samples may be shipped by commercial air cargo transporter. Personnel should be prepared to open and re-seal the cooler for inspection, if required. Some commercial carriers have a limit of 70 pounds per item.

- o Region V's "Sample Shipment Checklist: Low Concentration Samples" must be completed before any low concentration samples are shipped. Adherence to and proper completion of this checklist should ensure that all proper packaging and shipping procedures have been followed. (See example in Appendix 14-A).

14.3 PACKAGING AND SHIPPING HAZARDOUS SAMPLES (MEDIUM CONCENTRATION.)

14.3.1 Bottle and Preservation Requirements

See Chapter 5 for bottle selection and preservation requirements.

14.3.2 Paperwork

Follow the same chain-of-custody, receipt and traffic report procedures used for low concentration samples. See Appendix 14-A for examples.

14.3.3 Packaging and Shipping Procedures

Unanalyzed samples which have been deemed to contain potentially hazardous substances are packaged and shipped according to DOT regulations. If a material identified in the DOT Hazardous Material Table (49CFR172.101) is known to be present in a sample, that sample should be shipped as prescribed in the table.

Since the composition of a sample is generally never known, the use of Table 172.101 for shipment of hazardous waste samples is limited. For samples with unknown constituents, the sequence given in 49 CFR 173.2 should be used to determine under which hazard class a sample will be shipped. DOT Hazardous Classes are attached as Appendix 14-B.

Figure 14-1 is a decision logic diagram for determining which hazard class should be used for shipment of unknown samples. In most cases, medium concentration samples will be shipped as FLAMMABLE LIQUID OR SOLID, N.O.S.

The following is an outline of packaging procedures to be followed in shipping medium concentration samples:

The decontaminated, tagged and labeled sample container (typically, an 8-oz. glass jar) is placed in a 2 mil-thick self-sealing or heavy duty plastic bag, one sample per bag.

A half-gallon (preferred) or gallon metal paint can is prepared by placing some vermiculite in the bottom of the can to absorb shock and absorb the sample in the event of breakage. The sealed sample bag is then placed in the can and the remaining space filled with vermiculite. The can lid is then sealed in place with three metal clips.

The following labels are placed on the can: (The labels should be self-adhesive and not touch one another.)

- The name and address of the receiving laboratory. (Also record sample numbers here and place on can lid.)

- "Flammable liquid, N.O.S." (If liquid)

- "Flammable solid, N.O.S." (If solid)

- If semi-solid, or combined solid and liquid are encountered, use "Flammable Liquid, N.O.S.".

- "This End-Up" by drawing an arrow on can.

The can is then placed in a metal, plastic-lined ice cooler which has been partially filled with vermiculite. Additional vermiculite is added to fill the cooler. If more than one can is being shipped, this should be specified on the carrier's bill of lading. A copy of the chain-of-custody record as well as all required paperwork is sealed in a plastic bag and the cooler lid is shut and fastened. <u>NO ICE IS USED WITH MEDIUM CONCENTRATION SAMPLES.</u>

The over pack (i.e. cooler) is marked and labeled as follows:

- On top of the cooler, place:
  1) Name and address of receiving lab
  2) Flammable liquid, N.O.S. or
     Flammable solid N.O.S. sticker and corresponding UN number.
  3) Affix custody seals on front right and left rear of cooler. Cover seals with clear tape.

- On sides of the cooler place:
  1) "This End-Up" labels (all four sides)
  2) DOT Hazard Class (all four sides)
     i.e. Flammable Liquid,N.O.S. with UN number
     Flammable Solid, N.O.S. with UN number

3) "Danger-Peligro" (at least two sides)
   if net quantity of cooler exceeds passenger
   aircraft limitations

- o Region V's "Sample Shipment Checklist: Medium and High Concentration Samples" must be completed before any medium concentration samples are shipped. Proper completion of this checklist should ensure that all paper packaging and shipping requirements have been met. (See example in Appendix 14-A).

The Federal Express airbill with attached Shipper Certificate is filled out at the time the cooler is offered for shipment. An example of this document is shown in Appendix 14-A.

Personnel should be prepared to open and reseal the cooler if requested by the carrier. If amount of solid per cooler exceeds 25 pounds or amount of liquid per cooler exceeds 32 ounces, the samples must be shipped by Cargo Aircraft only.

14.4 PACKAGING AND SHIPPING HAZARDOUS SAMPLES (HIGH CONCENTRATION)

(Note: This procedure is for concentrated samples determined not to contain DOT Class A poisons.)

14.4.1 Bottles and Preservation Requirements

High concentration samples are never preserved or iced. See of Chapter 5 for bottle selection.

14.4.3 Paperwork

Follow the same chain-of-custody and receipt procedures used for low and medium-concentrated samples. See Appendix 14-A for examples of these documents.

The organic/inorganic traffic report is replaced by the high hazard traffic report. See Appendix 14-A for an example.

14.4.3 Packaging and Shipping Procedures

Packaging, marking and labeling procedures are the same as for medium concentration samples.

- o Completion of Region V's "Sample Shipment Checklist: Medium and High Concentration Samples" is required prior to shipment. See example in Appendix 14-A.

14.5 Residential Well Samples

At present, all residential well samples must be sent to the CRL for analysis due to the lower detection limits and quick turn around times that are required for the analysis of all drinking water samples, regardless of whether the samples are taken specifically to determine the quality of the drinking water. The following are guidelines to be followed whenever samples are shipped to the CRL.

- o Organic and Inorganic Traffic Reports, as well as case and/or SAS numbers, are not required for samples sent to the CRL. Instead, basic data forms are used in their place and are generally completed by the SMC prior to the actual sampling activity. These forms are used solely by the CRL for data tracking and review purposes. If sampling points are added to or deleted from the original plan, the SMC must be informed immediately so that the appropriate CRL numbers can be added or voided as necessary. If changes

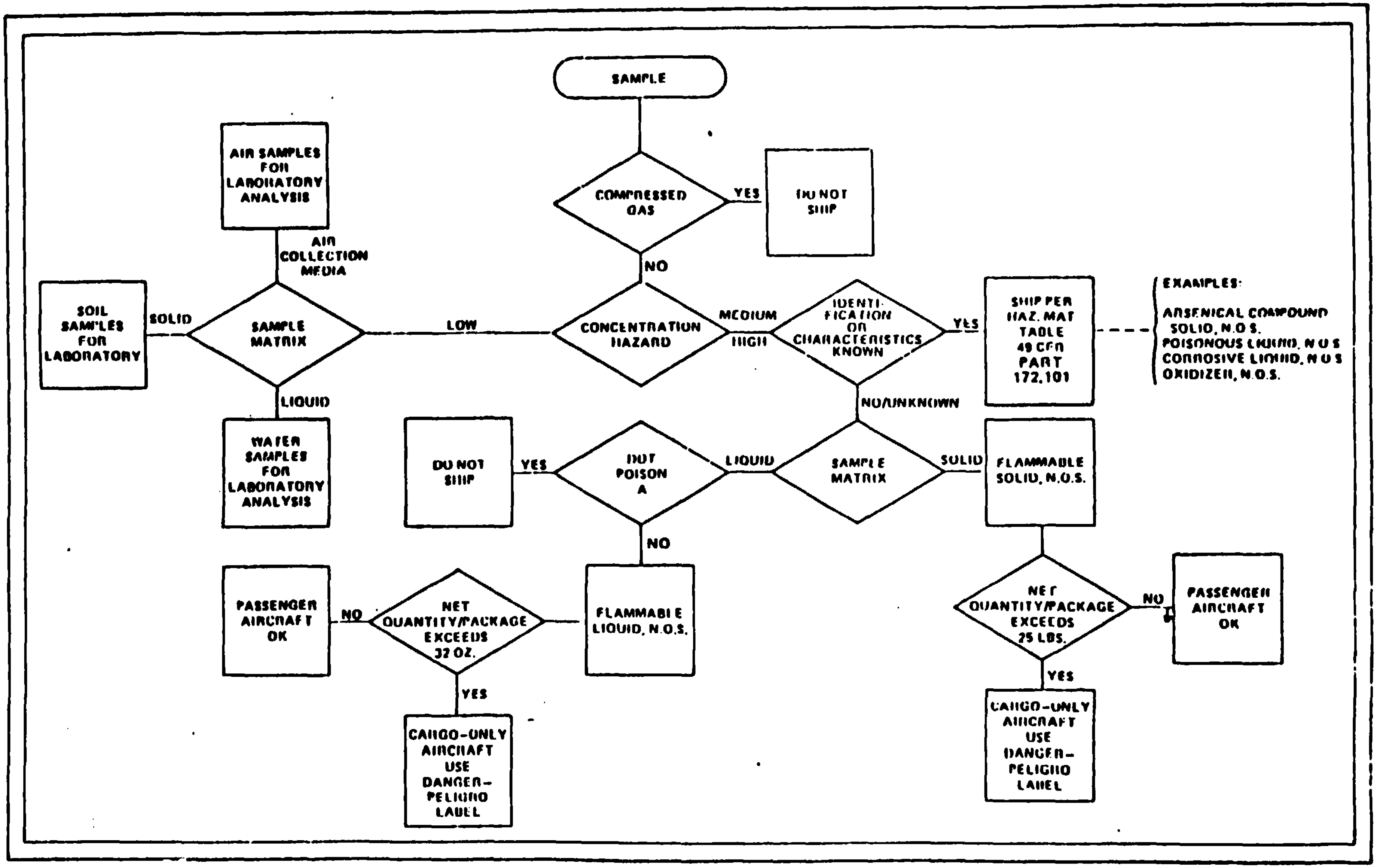


FIGURE 14-1 DECISION GUIDANCE FOR ASSIGNING A DOT PROPER SHIPPING NAME TO SAMPLES FOR SHIPMENT BY AIRCRAFT

must be made to the basic data form, white out can be used. All other paperwork commonly required for a sampling site remains the same. An example of a completed basic data form follows 14.5.8.

- The CRL number (explained in guideline 145.7) is assigned to each sample location and must be used in the same manner as a traffic report number. The only difference is that only one CRL number is assigned for both the organic and inorganic sample fractions. The CRL number must appear on the Avery labels and sample tags used for each sample as well as on the appropriate Chain-of-Custody.

  Organic and inorganic sample fractions may be packaged in the same cooler as long as the organics are sufficiently iced. If packaged in this manner, both the organic and inorganic sample information may appear on the same Chain-of-Custody.

- Organic sample bottle requirements for shipments to the CRL are the same as those for the Contract Labs. As always, a matrix spike duplciate must be included. The amber bottles sent for Acid/Base Neutral and Pesticide/PCB analysis should now be filled 1/2 to 2/3 full at each sample location. For the matrix spike duplicate, send one sample complement 1/2 - 2/3 full and two additional sample volumes completely full. The increased number of VOA samples will remain the same.

  Again, this would mean that for the matrix spike duplicate and corresponding sample a total of six amber bottles will be sent; two will be 1/2 - 2/3 full and four will be completely full.

The inorganic sample bottle requirements differ slightly for those samples sent to the CRL. The regular one liter bottle will yield all metals analysis normally received by the Contract Labs with the exception of mercury. If analysis for mercury is required, a special 250 ml bottle is available at the warehouse for this purpose. In addition, 5 mls of Potassium Dichromate must be used as a preservative and is also available at the warehouse. Cyanide analysis bottle requirements remain unchanged.

- All other packaging and shipping requirements for samples sent to the CRL are the same as for samples sent to the Contract Labs.

- The address for the CRL is:
  U.S. EPA Central Regional Lab
  536 S. Clark Street 10th Floor
  Chicago, Illinois 60605
  Attn: Bill Sargent

APPENDIX 14A

EXPLANATIONS FOR COMPLETING SAMPLING PAPERWORK

CRL BASIC DATA FORM

Division/Branch:	FIT
Sampling Date:	Self-explanatory
Lab Arrival Date:	This will be the next day if sent via Federal Express; or whenever samples are scheduled to arrive at the lab.
Due Date:	Count 21 days including lab arrival date and weekends. If due date falls on a weekend, the following Monday should be used instead.
DATA SET NUMBER:	Leave Blank
DU Number:	Y905
Study:	Site Name
Priority:	Leave Blank
Contractor:	Lab Name; C48100 codes samples analyzed by CRL.
CRL Numbers:	87FA01S09, R08, D09 87 - Fiscal Year F - FIT A - The first letter of last name of site team leader. 01 - The first sequence of numbers in first series of 100 sample numbers S09- The ninth sample assigned in the first series of 100 samples R08- The eight blank assigned in the first series of 100 samples D09- Duplicate of sample assigned number S09
Sample Description:	Whatever is appropriate description of the sample location. Tag#'s must also be recorded.

If the sampling date is known, all of the basic data form, excluding the sample description portion, can be completed prior to the actual sampling activity. The only part the sampler should need to complete in the field is the sample description.

ENVIRONMENTAL PROTECTION AGENCY
FOR THE TEAM: TOXIC SUBSTANCES

DIVISION/BRANCH FIT SAMPLE DATE 2/5/86 LAB ARRIVAL DATE 2/6/86 DUE DATE 2/26/86

DU NUMBER Y905 C48100 DATA SET NUMBER ______ STUDY Site Name PRIORITY ______ CONTRACTOR CRL

CRL LOG NUMBER	SAMPLE DESCRIPTION Location	TAG #s	WATER VOLATILE ORGANICS SCAN UG/L TOX 17564	WATER ABN ORGANICS SCAN UG/L TOX 17574	SEDIMENTS SOLIDS VOLATILE ORGANICS SCAN MG/KG (DRY) TOX 216622	SEDIMENTS SOLIDS ABN ORGANICS SCAN MG/KG (DRY) TOX 216722
86FA01S09	Well 1A	06149 06150	✓			
86FA01R08	Blank	06153 06154	✓			
86FA01D09	Dup 1A	06157 06158	✓			
86FA01S09	Well 1A	06151 06152		✓		
86FA01R08	Blank	06155 06156		✓		
86FA01D09	Dup 1A	06159 06160		✓		

SAMPLE TAG

A. GENERAL:

A sample tag is completed for every sample collected and attached to the sample container.

B. PREPARATION:

1.	Project Code	- Enter TDD number
2.	Station Number	- Enter sample point (station) code number; Code number must correlate with sample plan. Some examples:

Monitor well	= MW	Sediment	= SE
Existing well	= GW	Lake	= LK
Stream	= SW	Lagoon	= LG
Soil	= SO	Leachate	= LE
Sludge	= SL	Blank	= BL

3.	Month/Day/Year	- Self explanatory
4.	Time	- Use military format - i.e. 1430 for 2:30 P.M.
5.	Designate	- Comp (Composite) or grab (Check only one.)
6.	Station Location	- Enter sample point description. Field blanks are to be identified here.
7.	Samplers	- Enter signature of sampler.
8.	Preservative	- Yes or no (Check only one, add type of preserative)
9.	Analysis	- Check analysis desired.
10.	Remarks	- Enter Traffic Report number or SAS number.
11.	Tag Number	- Enter number in logbook, on custody sheet and/or Sample Description Form.

LOW and MEDIUM CONCENTRATION EXAMPLE

Project Code	Station No	Month/Day/Year	Time	Designate: Comp	Designate: Grab
TDD #	SITE SAMPLE #	*	*	X CS	X

Tag No	Station Location	Samplers (Signatures)
5-2249	SAME AS ON ALL FORMS	PERSON(S) COLLECTING SAMPLE

Lab Sample No: LEAVE BLANK

Remarks: ITR # or OTR #

ANALYSES: Bacteriology, Mutagenicity, Pesticides ✓ 8003, Volatile Organics ✓ VOA, Priority Pollutants ✓ 8003, Organics GC/MS ✓ 8003, Oil and Grease, Cyanide ✓ Cyanide liter, Metals ✓ liter metals, Mercury, Phenolics, COD, TOC, Nutrients, Solids (TSS)(TDS)(SS), BOD, Anions

Preservative: Yes [ ] No [ ] AS APPROPRIATE

HIGH CONCENTRATION EXAMPLE

Project Code	Station No	Month/Day/Year	Time	Designate: Comp	Designate: Grab
TDD #	SITE SAMPLE #	*	*	X CS	X

Tag No	Station Location	Samplers (Signatures)
5-2250	SAME AS ON ALL FORMS	PERSON(S) COLLECTING SAMPLE

Lab Sample No: LEAVE BLANK

Remarks: HCTR #

ANALYSES: Bacteriology, Mutagenicity, Pesticides, Volatile Organics, Priority Pollutants, Organics GC/MS, Oil and Grease, Cyanide, Metals, Mercury, Phenolics, COD, TOC, Nutrients, Solids (TSS)(TDS)(SS), BOD, Anions

Preservative: Yes [ ] No [ ]

* SELF EXPLANATORY

ORGANIC TRAFFIC REPORT

A. GENERAL:

The organic traffic report is used in conjunction with the shipment of the sample to the EPA contract lab for extractable and volatile organic analysis. One report is used at each sampling station and the same report is used for both analyses. This report must be completed in the field and shipped with the samples to the contract lab.

B. DISTRIBUTION:

1. First copy (white) - Mail to SMO.
2. Second copy (pink) - Send to CPMS CRL.
3. Third and fourth copy (white and yellow) - Ship with samples.

C. PREPARATION:

1. Case number - Supplied by SMO. Enter SAS number if applicable.
   Sample site name/code and enter TDD number - Self-explanatory
2. Sample concentration - Check "low" or "medium"; if "high conc.", use High Hazard Traffic Report.
3. Sample matrix - Check as appropriate.
4. Ship to - Name, address and point of contact at designated lab.
5. Regional office - Enter V-FIT.
   Sampling personnel - Enter samplers name and phone no.
   Sample Date - Enter date sample taken.
6. Number of containers and sample volume - Enter number of containers and volume for each analysis (i.e. Ext. or VOA). Use "other" for SAS parameters.
7. Shipping information - Enter FEDERAL EXPRESS or other carrier. Enter date shipped and air bill number.
8. Sample Description - Self-explanatory.
9. Sample Location - Enter sample point description; must match that described on corresponding tag and on chain of custody.
10. Special handling - Indicate if matrix spike duplicate sent
11. Items to remember - Enter traffic report numbers in log book and on custody form. Traffic reports must identify any designated field and trip blanks.

OTR Example

U.S. ENVIRONMENTAL PROTECTION AGENCY HWI Sample Management Office

ORGANICS TRAFFIC REPORT

Sample Number: EG 554

① **Case Number:** 5247

Sample Site Name/Code: Mason Landfill
R5-8505-08

② **SAMPLE CONCENTRATION** (Check One)

✓ Low Concentration
___ Medium Concentration

③ **SAMPLE MATRIX** (Check One)

___ Water
✓ Soil/Sediment

④ **Ship To:**
ATI
225 W. 30th St
National City, CA 92050

Attn: Bob Woods

Transfer Ship To:

⑤ **Regional Office:** V-FIT

Sampling Personnel: R Hix Mays (Name)
312-663-9415 (Phone)

Sampling Date: 11/21/85 (Begin) (End)

⑥ **For each sample collected specify number of containers used and mark volume level on each bottle.**

	Number of Containers	Approximate Total Volume
Water (Extractable)		
Water (VOA)		
Soil/Sediment (Extractable)	1	8 oz
Soil/Sediment (VOA)	2	240ml
Other		

EG 554 - Water (Extractab.
EG 554 - Water (Extractat
EG 554 - Water (VOA)
EG 554 - Water (VOA)
EG 554 - Soil/Sedim (Extractabl
EG 554 - Soil/Sedim. (Extractabl
EG 554 - Soil/Se..m (VOA)
EG 554 - Soil/Sedim (VOA)

⑦ **Shipping Information**

Federal Express
Name of Carrier

11/21/85
Date Shipped:

273617573
Airbill Number:

⑧ **Sample Description**

___ Surface Water ___ Mixed Media
___ Ground Water ✓ Solids
___ Leachate ___ Other (specify) ________

⑨ **Sample Location**

Soil S3

⑩ **Special Handling Instructions:**
(e.g., safety precautions, hazardous nature)

SMO COPY

recycled paper

INORGANIC TRAFFIC REPORT

A. GENERAL:

The Inorganic Traffic Report is used in conjunction with the shipment of the sample to the EPA contract lab for inorganic analysis. As was the case with the organic traffic report, one report is used at each sampling station and the same report is used for all inorganic analyses from that station. This report is also completed in the field and shipped with the samples to the contract lab.

B. DISTRIBUTION:

1. First copy (white) - Mail to SMO.
2. Second copy (pink) - Send to CPMS, CRL.
3. Third and fourth copy (white and yellow) - Ship with samples.

C. PREPARATION:

1. Case number - supplied by SMO. Enter SAS number if applicable. Sample site name/code and enter TDD Number - self explanatory
2. Sample concentration - Check "low" or "medium"; if sample concentration is "high", must use special "High Hazard Traffic" Report Form.
3. Sample Matrix - Check "water" or "soil/sediment".
4. Ship to: Enter name, address and contact of contractor laboratory receiving sample.
5. Sampling office - Enter V-FIT.
   Sampling personnel - Enter name and phone number of E & E sampler.
   Sampling date - Grab sample date or, if applicable, dates of composite.
6. Shipping information - Federal Express or other carrier name, date shipped, and airbill number.
7. Sample description - Self-explanatory.
   Add sample location description to this block. Must match tag and chain of custody.
   Matches organic sample number - If applicable, enter matching organic traffic report number.
8. Mark volume level on sample bottle - Check analysis required; enter SAS parameters here if applicable; attach traffic report stickers to appropriate samples.
9. Traffic reports must identify and designate field and trip blanks.

ITR Example

U.S. ENVIRONMENTAL PROTECTION AGENCY HWI Sample Management Office

INORGANICS TRAFFIC REPORT

Sample Number
MEE 166

(1) **Case Number:** 5247
Sample Site Name/Code:
Mason Landfill
RS-8505-08

(2) **SAMPLE CONCENTRATION**
(Check One)
✓ Low Concentration
___ Medium Concentration

(3) **SAMPLE MATRIX**
(Check One)
___ Water
✓ Soil/Sediment

(4) **Ship To:**
RMAL
5530 Marshall St
Arvada, CO 80002
Attn: Tony Maiurana

Transfer Ship To:

(5) **Sampling Office:** V-FIT
Sampling Personnel:
(Name) R. Hix Mays
(Phone) 312-663-9415
Sampling Date:
(Begin) 11/21/85 (End) 11/21/85

(6) **Shipping Information:**
Name Of Carrier:
Federal Express
Date Shipped: 11/21/85
Airbill Number: 273617549

(7) **Sample Description:**
(Check One)
___ Surface Water
___ Ground Water
___ Leachate
___ Mixed Media
✓ Solids
___ Other Soil S3
(specify)
MATCHES ORGANIC SAMPLE NO. EG554

(8) **Mark Volume Level On Sample Bottle**
Check Analysis required
✓ Total Metals
✓ Cyanide

MEE 166	· Total Metals
MEE 166	· Total Metals
MEE 166	· Cyanide
MEE 166	· Cyanide
MEE 166	
MEE 166	
MEE 166	

SMO COPY

recycled paper

ecology and environment

HIGH HAZARD TRAFFIC REPORT

A. GENERAL:

The High Hazard Traffic Report is only used when the sample is considered to be a high concentration sample.

B. DISTRIBUTION:

1. First copy (white) - Mail to SMO.
2. Second copy (pink) - Send to CPMS, CRL.
3. Third and fourth copy (white and yellow) - Ship with samples.

C. PREPARATION:

1. Case number - obtained from SMO. Enter SAS number if applicable. Sample site name and enter TDD number - self explanatory.
2. Field sample description - Self explanatory.
3. Ship to - Enter name, address, and contact of laboratory receiving samples.

   Sampling office - Self explanatory.

5. Known or suspected hazards - Self explanatory.
6. Sample location - Enter sample point description; must match that description on the corresponding tag and on chain of custody.
7. Preparations requested - Self explanatory.
8. Shipping information - Self explanatory.
9. Special instructions - Self explanatory.

EXAMPLE

U.S. ENVIRONMENTAL PROTECTION AGENCY CLP Sample Management Office
PO Box 818—Alexandria, Virginia 22313 Phone 703-557-2490—FTS/557-2490

HIGH HAZARD TRAFFIC REPORT

Sample Number: E 5257

FIELD SAMPLE RECORD

① **Case Number:** From USEPA Sample Coordinator/SMO contact **Sample Site Name/Code:** TDD # Site Name	② **Field Sample Description:** _ Drum _ Aqueous Liquid _ Sludge _ Solid _ Oil _ Other ____ CHECK AS APPROPRIATE	③ **Ship To:** Lab Name & Address **Attn:**
④ **Sampling Office:** * REGION V-FIT **Sampling Personnel:** * (name) Office Number (phone) **Sampling Date:** Collection Date Use Begin & End for Composite Sample (begin) (end)	⑤ **Known or Suspected Hazards:** Important! List any historical or suspected hazards. If nothing known, write "unknown". DO NOT LEAVE BLANK.	⑥ **Sample Location:** Use same description as on other forms
⑧ **Shipping Information:** * FEDERAL EXPRESS (name of carrier) * (date shipped) * (airbill number)	⑦ **Preparations Requested:** (check below) **Sample Volume:** ____ — Organics — Volatile Organics — Base/Neutral Acid — TCDD — Pesticides, PCB — Inorganics — Total Metals — Total Mercury — Strong Acid Anions Check desired parameters (usually all!)	HHTR-Traffic Report Labels Here (PEEL OFF LABELS)

⑨ **Special Handling Instructions:**

* Self Explanatory

SMO Copy

SPECIAL ANALYTICAL SERVICE PACKING LIST

A. General

The SAS Packing List is used in conjunction with the shipment of the sample to the EPA contract lab for special analytical services only. If the lab is to perform both RAS and SAS analyses, an SAS Packing List is not needed. The SAS parameters are simply written on the inorganic, organic, or high hazard traffic report.

B. Distribution

1. First copy (white) - mail to SMO
2. Second copy (pink) - Retain in regional FIT file (photocopy sent to CPMS, CRL).
3. Third and fourth copy (white and yellow) ship with samples

C. Preparation

1. Sampling office - Region V-FIT
   Sampling contact - E&E sample management coordinator and phone no.
2. Sampling Date - date samples were obtained
   Date shipped - self explanatory
   Site Name/Code - Site name and TDD number. White and yellow copies only.
3. Laboratory's name and address, name on CLP addresss list for "Attn."
4. Sample Numbers - Use SAS Number -101 etc, for example 2055E01, 2055E02, ... Use additional Packing Lists if necessary.
5. Clearly state the analysis, matrix, and concentration. Also state the sample location description.
6. For Lab use only - do not fill in.
7. For Lab use - do not fill in.

U.S. ENVIRONMENTAL PROTECTION AGENCY
CLP Sample Management Office
P.O. Box 818 - Alexandria, Virginia 22313
Phone: 703/557-2490 - FTS/557-2490

SAS Number
2055E

SPECIAL ANALYTICAL SERVICE
PACKING LIST

Sampling Office:	Sampling Date(s):	Ship To:	For Lab Use Only
Region V - FIT	11/21/85	Versar, Inc 6850 Versar Center Springfield, VA 22151	Date Samples Rec'd:
Sampling Contact: Renée Hix-Mays (name)	Date Shipped: 12/5/85		Received By:
312-663-9415 (phone)	Site Name/Code: Northside/R5-8402-20	Attn: Bill Nivens	

Sample Numbers	Sample Description – As appropriate i.e., Analysis, Matrix, Concentration	Sample Condition on Receipt at Lab
1. 2055E01	NSL-LL04-02	
2. 2055E02	NSL-LL05-02	
3. 2055E03	NSL-LL06-02	
4. 2055E04	NSL-LL07-02	
5. 2055E05	NSL-LL08-02	
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.	Water samples analyzed for	
14.	specific conductance, pH, chloride,	
15.	sulfate, TOC, COD	
16.		
17.		
18.		
19.		
20.		

For Lab Use O…

White - SMO Copy, Yellow - Region Copy, Pink - Lab Copy for return to SMO, Gold - Lab Copy

recycled paper

ecology and environment

SAMPLE CUSTODY SEAL

This seal is placed on the front and back edges of the over-pack, i.e. cooler in such a manner that attempts to open the cooler will cause damage to the seal.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION V
OFFICIAL SEAL
№ 37677

FEDERAL EXPRESS AIRBILL

A. GENERAL:

All samples collected will either be hand delivered to the lab by surface means or will be shipped to the lab by Federal Express. To insure timely delivery of the samples, the Federal Express Airbill must be completed correctly.

B. DISTRIBUTION:

The shipper's copy (pink) of the airbill must be retained by the FIT sampler at the time of shipment. This copy is given to the Administrative Assistant.

All other copies of the airbill are retained by Federal Express.

C. PREPARATION:

1. Block 1 - Enter shipper's name and the E & E warehouse address and phone number in Chicago.
2. Block 2 - Enter the address and phone number of the contract lab and the designated lab contact.
3. Block 3 - Reference number - Enter SAM + 8-digit TDD number,and job number.
   Payment - Check third party F.E.C. Account.
   Account number/credit card - Enter 200-77514.
4. Block 4 - Services - Check Box #1, "Overnight Packages".
   Delivery - Check Box #2, "Deliver".
   If shipping on a Friday, check Box #3, "Saturday service required".
   Enter number of coolers being sent to the contract lab.
   REMEMBER TO RETAIN PINK COPY.

FEDERAL EXPRESS

USE THIS AIRBILL FOR DOMESTIC SHIPMENTS AND FOR SHIPMENTS FROM PUERTO RICO TO THE U.S.A.
FILL OUT PURPLE AREAS. FOR ASSISTANCE, CALL 800-238-5355, TOLL FREE.
SEE BACK OF FOURTH SET FOR COMPLETE PREPARATION INSTRUCTIONS.

AIRBILL NUMBER

SENDER'S FEDERAL EXPRESS ACCOUNT NUMBER | DATE

51058 0605-6293-8

1 From (Your Name) | Your Phone Number (Very Important) ( )

Company: ECOLOGY & ENVIRONMENT INC | Department/Floor No.

Street Address: 5634 N. Northwest Hwy

City: CHICAGO | State: IL

ZIP *Zip Code Required For Correct Invoicing: 60646

AIRBILL NO 276074971

2 To (Recipient's Name): LAB ATTN: NAME | Recipient's Phone Number (Very Important) ( )

Company: LABORATORY | Department/Floor No.

Exact Street Address (Use of P.O. Boxes or P.O. • Zip Codes Will Delay Delivery And Result in Extra Charge.): ADDRESS

City | State

ZIP Street Address Zip Required (No P.O. Box • Zip Codes)

3 YOUR BILLING REFERENCE INFORMATION (FIRST 24 CHARACTERS WILL APPEAR ON INVOICE.): SAM (TDD #) (Job # CH633-S)

PAYMENT ☐ Bill Shipper ☐ Bill Recipient's FedEx Acct. No. Fill in acct. below ☒ Bill 3rd Party FedEx Acct. No. Fill in acct. below ☐ Bill Credit Card Fill in acct. below ☐ Cash

FedEx Acct. No. or Major Credit Card No.: 0200-7751-0

H HOLD FOR PICK-UP AT THIS FEDERAL EXPRESS STATION
Street Address (See Service Guide or Call 800-238-5355)
City | State
ZIP *Zip Code of Street Address Required

4 SERVICES CHECK ONLY ONE BOX

PRIORITY 1
1 ☒ Overnight Delivery Using Your Packaging

OVERNIGHT LETTER
6 ☐ Our Packaging 9"x12"

OVERNIGHT DELIVERY USING OUR PACKAGING
2 ☐ Courier-Pak Overnight Envelope 12" x 15½"
3 ☐ Overnight Box 12⅞" x 17⅝" x 3"
4 ☐ Overnight Tube 38" x 6" x 6" x 6"
A ☐
B ☐

STANDARD AIR
5 ☐ Delivery not later than second business day

SERVICE COMMITMENT

DELIVERY AND SPECIAL HANDLING CHECK SERVICES REQUIRED
1 ☐ HOLD FOR PICK-UP Give the Federal Express address where you want package held in Section H at right.
2 ☒ DELIVER WEEKDAY
3 ☐ DELIVER SATURDAY (Extra charge applies)
4 ☐ RESTRICTED ARTICLES SERVICE (P-1 and Standard Air Packages only. Extra charge applies)
5 ☐ CONSTANT SURVEILLANCE SERVICE (CSS) (Extra charge applies)
6 ☐ DRY ICE ______ Lbs.
7 ☐ OTHER SPECIAL SERVICE ______
8 ☐
9 ☐ SATURDAY PICK-UP OR SATURDAY DROP-OFF (Extra charge applies)

PACKAGES	WEIGHT	YOUR DECLARED VALUE (See right)	OVER SIZE
Total	Total	Total	

Received At
Shipper's Door
☐ Regular Stop
☐ On-Call Stop
☐ FedEx Loc. ______

Federal Express Corp. Employee No.

Date/Time For Federal Express Use

YOUR DECLARED VALUE

DAMAGE OR LOSS

DELAY

CONSEQUENTIAL DAMAGES

Federal Express Use
Base Charges
Declared Value Charge
Origin Agent Charge
Other
Total Charges

PART #2041738901 FEC-S-751-1000 REVISION DATE 10/84 PRINTED U.S.A. GBF

CHAIN OF CUSTODY RECORD

A. GENERAL:

A chain-of-custody form must be completed for each cooler shipped.

B. DISTRIBUTION:

1. First copy (white) - Shipped with samples.
2. Second copy (pink) - Retained in FIT regional files.
3. Third copy (yellow)- Returned to FIT office and forwarded to CRL.

C. PREPARATION:

1. Project Number - Enter TDD number.
2. Project Name - Enter site name and case number.
3. Samplers - Enter signatures of all samplers who have signed sample tags.
4. Station Number - Enter sample points.
5. Date - Enter sampling date.
6. Time - Enter sampling time; use miltary time.
7. Comp - Check if sample is composite.
8. Grab - Check if sample is grab.
9. Station Location - Enter sample location description which must match that on tags and traffic reports.
10. No. of Containers - Enter number of containers collected at each station number (point).
11. Inside Slanted Lines- Enter analytical group or parameter desired.
12. Remarks - Enter matching traffic report numbers and indicate sample matrix and concentration. Add bottle lot numbers for all types of bottles used.

13.	Relinquished by	- Signature of one of the samplers. Must match "samplers" at top of custody record.
14.	Date/Time	- Enter date and time samples are relinquished to laboratory or shipping carrier.
15.	Received by lab	- Signature of individual in laboratory who signed for samples.
16.	Remarks (lower right hand corner)	- Enter laboratory shipped to, method of shipment, airbill number, and custody seal numbers.

Inorganic C.O.C. Example

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

REGION 5
230 South Dearborn Street
Chicago, Illinois 60604

CHAIN OF CUSTODY RECORD

PROJ. NO. 85-8505.08 **PROJECT NAME** Mason Landfill / case 5247

SAMPLERS: *(Signature)* Renée Hsp May

STA. NO.	DATE	TIME	COMP	GRAB	STATION LOCATION	NO. OF CONTAINERS	1 liter/metals	1 liter/cyanide	8 oz metals & cyanide			REMARKS: Low concentration — ITR	OTR	Matrix
B1	11/21/85	15:30		X	Blank	2	1	1				MEC278	EC964	water
W1	11/21/85	14:00		X	Well W1	2	1	1				MEC277	EE963	water
W2	11/21/85	13:45		X	Well W2	2	1	1				MEC279	EE965	water
S1	11/21/85	14:05		X	Soil S1	1			1			MEC280	EE966	soil
S2	11/21/85	14:15		X	Soil S2	1			1			MEC281	EE967	soil
S3	11/21/85	14:30		X	Soil S3	1			1			MEC166	EG 554	soil

Water metals are filtered

Lot # - liter - 35266162
8oz - 45159132

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Renée Hsp May	11/21/85 17:00				

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks
				Shipped Federal Express to RMAL Airbill - 21961549 Custody seals - 38029, 38030

Distribution: White -- Accompanies Shipment, Pink -- Coordinator Field Files; Yellow -- Laboratory File

Organic C.O.C. Example

ENVIRONMENTAL PROTECTION AGENCY
Office of Enforcement

CHAIN OF CUSTODY RECORD

REGION 5
230 South Dearborn Street
Chicago, Illinois 60604

PROJ. NO.: R5-8505-08
PROJECT NAME: Mason Landfill / Case #5247

SAMPLERS: (Signature) Renée Ho Mary

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	80z Organics	40ml VOA	8oz Organics	120ml VOA			REMARKS: Low concentration — OTR	ITR	Matrix
B1	11/21/85	15:30		X	Blank	4	2	2					EE964	MEE278	water
W1	11/21/85	14:00		X	Well W1 (MSD)	8	4	4					EE963	MEE277	water
W2	11/21/85	13:45		X	Well W2	4	2	2					EE965	MEE279	water ~~soil~~ RHM 11-21-85
S1	11/21/85	14:05		X	Soil S1	3			1	2			EE966	MEE280	soil
S2	11/21/85	14:15		X	Soil S2	3			1	2			EE967	MEE281	soil
S3	11/21/85	14:30		X	Soil S3	3			1	2			CG554	MEG166	soil

Lot # 80z - 15266112
40ml - 25157192
8oz - 45159132
120ml - 65159072

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Renée Ho Mary	11/21/85 17:00				
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks: Shipped Federal Express to A.T.E. Airbill - 2130[illegible] Cust. seals: 38027, 38028	

Distribution: White — Accompanies Shipment; Pink — Coordinator Field Files; Yellow — Laboratory File

LOW & MEDIUM CONC. EXAMPLE

RECEIPT FOR SAMPLES

... NO.	PROJECT NAME	Name of Facility
TDD#	Site Name (from TDD)	Actual Facility Name

SAMPLERS: (Signature)

ALL SIGNATURES OF THOSE INVOLVED

Split Samples Offered ( ) Accepted OR ( ) Declined

Facility Location

Street Address No P.O. Box Numbers
City, State

STA NO	DATE	TIME	COMP	GRAB	SPLIT SAMPLES	Organic/Inorganic Traffic Report #'s	STATION DESCRIPTION	NO. OF CON-TAINERS COLLECTED	REMARKS SAMPLE MATRIX
Site Sample#	*	*	X	OR X	Yes OR No	ME9823/E1217	Same as on all forms		indicate if solid, liquid, or sediment

Note: This form is required even if split samples are refused.

Transferred by: (Signature)	Received by: (Signature)	Telephone
Samplers Above	Signature of Site Official	AREA CODE AND #

Date	Time	Title	Date	Time
*		*		

* SELF EXPLAINATORY

Receipt For samples

SHIPPER'S CERTIFICATE FOR RESTRICTED ARTICLES

A. GENERAL

The Shipper's Certificate for Restricted Articles is a required and necessary document when hazardous materials are to be transported by a carrier. Several reference sources may be consulted to complete the Shipper's Certificate, i.e. IATA, ICAO or 49CFR172; any reference source may be used as long as all entries on all shipping forms are consistent. Those substances designated as hazardous materials by the Department of Transportation are presented in the Hazardous Materials Table, 49CFR172.101. The requirements and explanations regarding shipping papers are described in 49CFR172.204. Because of severe penalties incurred by shippers for improper shipments of hazardous materials, any questions concerning the correct completion of the shipping forms should be directed to Federal Express. Call 1-800-2385355, Extension 3853,8 AM to 8PM Central time.

B. DISTRIBUTION

Depending on the manufacturer of the Shipper's Certificate, four or five copies of the form may be provided.

1. At least two copies of the certificate must be provided to the carrier for shipping and accounting purposes. (Four copies for Federal Express).

2. One copy for Region V FIT files. (Pink copy of the Federal Express form.)

C. PREPARATION (for Aircraft)

1. Limitations regarding quantities of hazardous materials for air shipment are outlined in columns 6a and 6b of the *Hazardous Materials Table (49 CFR 172.101). Identify* whether the package is to be shipped by passenger or cargo-only aircarft.

   a. Samples taken by FIT members to be analyzed are considered to have unknown constituents. In this case, the Hazardous Materials Table is referenced for the most appropriate shipping description. The most common (and legally acceptable) designations are: flammable solids, N.O.S., flammable liquid, N.O.S., or hazardous substance, liquid or solid, N.O.S. Depending on the shipping description selected, follow the precisely prescribed limitations for air shipments.

   b. When shipping known chemical compounds, consult the Hazardous Materials Table using the proper shipping name of the chemical. Follow the precisely prescribed limitations indicated for air shipments.

2. Number of Packages. Indicate the number of coolers being sent which have the same shipping name and destination.

3. 49 CFR Requirements. Check this box at the top of the shippers certification.

4. Proper Shipping Name. Indicate the proper shipping name of the Hazardous Materials Table. (See 1 above.) DO NOT ABBREVIATE.

5. <u>Class</u>. Indicate the hazard class of the article as shown in column 3 of the Hazardous Materials Table. This category also requires the listing of the Identification Number found in column 4 of the above Table, if not specifically addressed in the Shipper's Certificate. DO NOT ABBREVIATE.

6. <u>Indentification Number</u>. Record the identification number (UN or NA) located in column 4 of the Hazardous Materials Table.

7. <u>Subsidiary Risk</u>. Leave blank when following 49 CFR 172 regulations.

8. <u>Net Quantity.</u> Indicate the quantity, weight or volume, of the collective samples within a single cooler.

9. <u>Packing Instruction.</u> Leave Blank.

10. <u>Authorization</u>. Leave Blank.

11. <u>Shipper's Information</u>. Complete spaces on the Shipper's Certificate detailing the shipper's name and address (field location, if appropriate), the specific individual sending the package and the date.

12. NOTE: If the shipment is for Cargo Aircraft Only, somewhere in the body of the form, usually under the proper shipping name, write "CARGO AIRCRAFT ONLY". See example.

13. NOTE: FIT shipments qualify as limited quantity if specifications in Column 5A of the Hazardous Material Table are satisfactorily met. If so write "LIMITED QUANTITY" at the bottom of the dangerous goods identification section (see example). This designation permits the shipment of hazardous materials under less stringent packaging criteria than normally required.

14. Transport Details. In this section write "NOTE: samples for laboratory analysis". Circle passenger aircraft or cargo only aircraft as appropriate. Cargo only aircraft must be circled if liquid quantity per cooler exceeds 32oz or if solid quantity per cooler exceeds 25lbs.

FEDERAL EXPRESS

USE THIS AIRBILL FOR RESTRICTED ARTICLES SHIPMENTS. FILL OUT PURPLE AREAS. FOR ASSISTANCE, CALL 800-238-5355. TOLL FREE. SEE FOR RESTRICTED ARTICLES ... SEE BACK OF FORM ... FOR COMPLETE INSTRUCTIONS.

MED & HIGH CONC. LIQUID EXAMPLE

AIRBILL NUMBER 421421766

SENDER'S FEDERAL EXPRESS ACCOUNT NUMBER: 0603-6293-8 | DATE:

1 From (Your Name): | Your Phone Number (Very Important): ( )

Company: Ecology & Environment, Inc | Department/Floor No.:

Street Address: 5634 N. Northwest Hwy

City: Chicago | State: IL

ZIP (Zip Code Required For Correct Invoicing): 60646

AIRBILL NO. 421421766

2 To (Recipient's Name): LAB ATTN: NAME | Recipient's Phone Number (Very Important): ( )

Company: LABORATORY | Department/Floor No.:

Exact Street Address (Use of P.O. Boxes or P.O. Zip Codes Will Delay Delivery And Result in Extra Charge): ADDRESS

City: | State:

ZIP Street Address Zip Required

3 YOUR BILLING REFERENCE INFORMATION (FIRST 24 CHARACTERS WILL APPEAR ON INVOICE.): SAM (TDD #) (Job # CH633-5)

PAYMENT: ☐ Bill Shipper ☐ Bill Recipient's FedEx Acct. No. ☒ Bill 3rd Party FedEx Acct. No. ☐ Bill Credit Card ☐ Cash — FedEx Acct. No. or Major Credit Card No.: 0200-7751-4

H HOLD FOR PICK-UP AT THIS FEDERAL EXPRESS STATION: Street Address (See Service Guide or Call 800-238-5355) | City | State | ZIP (Zip Code or Street Address Required)

4 SERVICES — CHECK ONLY ONE BOX

PRIORITY 1
- ☒ Overnight Delivery Using Your Packaging. When using ICAO regulations please mark appropriate box(es). Do not mark for CFR 49.
- ☐ Cargo Aircraft only
- ☐ Dangerous goods as per attached Dangerous Goods Transport Document

STANDARD AIR
- 5 ☐ Delivery not later than second business day

SERVICE COMMITMENT: PRIORITY 1 — Delivery is scheduled early next business morning in most locations. It may take two or more business days if the destination is outside our primary service areas. STANDARD AIR — Delivery is generally next business day or not later than second business day. It may take three or more business days if the destination is outside our primary service areas.

DELIVERY AND SPECIAL HANDLING — CHECK SERVICES REQUIRED
1. ☐ HOLD FOR PICK-UP Give the Federal Express address where you want package held in Section H at right. Restricted Articles hold service is not available at Business Service Centers.
2. ☐ DELIVER WEEKDAY
3. ☐ DELIVER SATURDAY (Extra charge applies)
4. ☒ RESTRICTED ARTICLES SERVICE (P-1 and Standard Air Packages only; extra charge applies)
5. ☐ CONSTANT SURVEILLANCE SERVICE (CSS) (Extra charge applies)
6. ☐ DRY ICE ______ lbs.
7. ☐ OTHER SPECIAL SERVICE ______
8. ☐
9. ☐ SATURDAY PICK-UP OR SATURDAY DROP-OFF (Extra charge applies)

PACKAGES	WEIGHT	YOUR DECLARED VALUE	OVER SIZE
Total	Total	Total	

Received At: ☐ Shipper's Door ☐ Regular Stop ☐ On-Call Stop ☐ FedEx Loc. ______

Federal Express Corp. Employee No.

Date/Time For Federal Express Use

YOUR DECLARED VALUE

DAMAGE OR LOSS — We are liable for no more than $100 per package in the event of physical loss of or damage, unless you fill in a higher Declared Value to the left and document higher actual loss in the event of a claim. We charge 30¢ for each additional $100 of declared value up to the maximum shown in our Service Guide. Declared value restrictions are shown on the back of the Shipper's Copy of this airbill. We make no express or implied warranties.

DELAY — There is always a risk of late delivery or non-delivery. In the event of a late delivery Federal Express will, at your request, refund all transportation charges paid. See back of Shipper's Copy of this airbill for further information.

CONSEQUENTIAL DAMAGES — We are not be responsible or liable for any loss or damage resulting from delay, non-delivery or damage to a shipment except as noted above. This includes loss of sales, income, interest, profits, attorney's fees, costs and other losses, but is not limited to those losses. Such damages are specifically waived.

Federal Express Use: Base Charges | Declared Value Charge | Origin Agent Charge | Other | Total Charges

PART # 2041130761

REVISION DATE 1/85 PRINTED U.S.A. NCR

ORIGIN COPY

AIRBILL NUMBER 421421766 (#3)

SHIPPER'S CERTIFICATION FOR RESTRICTED ARTICLES/DANGEROUS GOODS

CHECK ONE ➡ ☒ 49 CFR ☐ ICAO (TYPE OR PRINT)

[illegible] AUTHORIZATION

# of Coolers #2	FLAMMABLE LIQUID, NOS #4	FLAMMABLE LIQUID #5	UN1993 #6	#7	# of jars x oz. in each #8	#9	#10

#12 CARGO AIRCRAFT ONLY (WRITE IF NET QTY >32 oz)

#13 LTD QTY (ALWAYS WRITE THIS)

ADDITIONAL DESCRIPTION REQUIREMENTS FOR RADIOACTIVE MATERIALS (SEE BACK)

[illegible] LABELS: ☐ WHITE I ☐ YELLOW II ☐ YELLOW III ☐ NONE | TRANS. INDEX | PACKAGE IDENTIFICATION

(#14) NOTE: SAMPLES FOR LABORATORY ANALYSIS

TRANSPORT DETAILS — THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR ▶ <32 oz PASSENGER AIRCRAFT — CARGO AIRCRAFT ONLY >32 oz (DELETE-NONAPPLICABLE)

AIRPORT OF DEPARTURE | AIRPORT OF DESTINATION | SHIPMENT TYPE ▶ NON-RADIOACTIVE RADIOACTIVE (DELETE-NONAPPLICABLE)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS OR TREATMENT.

(#11) I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT BY AIR ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

NAME AND TITLE OF SHIPPER: YOUR NAME & TITLE | PLACE AND DATE: Shipment origin / date

EMERGENCY TELEPHONE NUMBER: 312-663-9415 | SIGNATURE OF SHIPPER: YOUR SIGNATURE

SEE WARNING ON BACK

Sampler's books and Records

I. Accountable Documents Records

Samplers are responsible for every accountable document assigned to them. The following is an example of the tracking format to be followed.

Document #	Site Name/TDD#/CASE#	Date Used	Date Voided

The format above should be followed for each type of document (OTR, ITR, HCTR, Sample Tag, Chain-of-Custody, Custody Seals) individually.

As soon as assigned a group of documents, enter their numbers in the "Document #" column only. Enter information in the remaining three columns after returning from the field when numbers have definitely been used. Tracking of documents assigned but not used are the samplers responsibility. The main concern is the final assignment of samplers documents.

Voided forms should be entered thusly and returned to the SMC.

NOTE: This record should remain in the office at all times.

II. A field log should be maintained containing the following information. The exact format is left up to the individual sampler.

Site Name__________________TDD______________Case #_________

OTR	IRT	HCTR	Complete Sample Description

III. <u>Sample Description Form</u>

The attached "Sample Description" form (see next page) should be completed from field notes as soon as possible after returning from the field. Both the SMC and the team leader receive a copy of these forms. The description should include both a physical description of the sample (i.e. cloudy, yellow, liquid with oil layer...) and formal description of the sampling location (the description written on traffic report).

The sampler will be responsible for conveying this information to their team leaders when requested. Therefore, team leaders should see their samplers when requesting this information for data interpretation and report preparation.

SAMPLE DESCRIPTION

SITE NAME/TDD# ____________________

CASE NUMBER ____________________

____

SAMPLE #/STATION LOCATION ____________________

____

SAMPLING DATE ____________________ SAMPLING TIME ____________________

ORGANIC TRAFFIC NUMBER E__________

INORGANIC TRAFFIC NUMBER ME__________

BOTTLE	ANALYSIS	TAG NUMBERS	LOT NUMBER

PHYSICAL DESCRIPTION AT TIME OF COLLECTION: ____________________

____

____

PHYSICAL CHANGES FROM TIME OF COLLECTION UNTIL SHIPMENT: ____________________

____

____

INSTRUMENT READINGS ____________________

pH ____________________

CONDUCTIVITY ____________________

TEMPERATURE ____________________

IV. Sample shipment checklist and photographs of coolers

The appropriate "Sample Shipment Checklist" form must be completed for each sampling case shipped. In the event that shipment for a particular case number occurs over several days, one form must be completed for each day of shipment. This form should be returned to the SMC along with the rest of the paperwork by the Monday after sampling is completed.

Photographs of each cooler, showing custody seals, labeling, and proper sample packaging and ice (when applicable), should be mounted on photo logs sheets and turned in to the sample manager as soon as possible after sampling is complete.

Site Name: ______________
Location: ______________
Case Number: ______________

SAMPLE SHIPMENT CHECKLIST:
LOW CONCENTRATION SAMPLES

Mark each item with an "X" to verify completion.

_______ 1. Is each sample bottle permanently labeled with the following information: Sample number, date, time of collection, and a brief description?

_______ 2. Are sample volumes marked on all sample bottles (except VOA's)?

_______ 3. Is each sample bottle lid secured with strapping tape or evidence tape?

_______ 4. Have all bottles been packed in plastic bags?

_______ 5. Are all samples properly preserved and iced, when appropriate, for shipment?

_______ 6. Are samples packaged in such a way as to prevent breakage?

_______ 7. Has the proper cushioning material (ie-vermiculite) been used for sample packaging?

_______ 8. Is each cooler drain taped shut?

_______ 9. Have all coolers been labeled with the proper laboratory address and has this label been covered with clear tape?

_______ 10. Has each cooler been labeled with "This Side Up" stickers on all four sides and "Fragile" stickers on at least two sides?

_______ 11. Is there at least one Chain-Of-Custody record per cooler?

_______ 12. Have the proper sections of the sampling paperwork been put in a plastic bag and taped to the inside lid of the coolers?

_______ 13. Has each cooler been secured properly with strapping tape?

_____ 14. Have numbered custody seals been affixed to the front right and back left of each cooler and covered with clear tape?

_____ 15. Has the sampler double-checked all paperwork and packiging procedures for accuracy and completeness immediately prior to strapping each cooler for shipment?

_____ 16. Have photos of each cooler, showing ice, custody seals, and proper packaging procedures, been taken?

I certify that all the above procedures have been followed and that all coolers have been properly packaged for shipment.

X ____________________ Sampler Signature

X ____________________ Team Leader Signature

NOTE: If there is any question that one of the above has been done incorrectly by any member of your team, DO NOT ship samples without checking your suspicions (even if this means re-opening coolers that have already been strapped shut!)

45T:6M

Site Name: ________________
Location: ________________
Case Number: ________________

SAMPLE SHIPMENT CHECKLIST:
MEDIUM AND HIGH CONCENTRATION SAMPLES

Mark each item with an "X" to verify completion.

_______ 1. Have the outsides of all sample bottles been decontaminated?

_______ 2. Is each sample bottle permanentaly labeled with the following information: sample number, date, time of collection, and a brief description?

_______ 3. Is each sample bottle lid secured with strapping tape or evidence tape?

_______ 4. Are all samples placed in plastic bags and positioned so the tags may be read?

_______ 5. Is each sample packed in a metal can?

_______ 6. Is each metal can secured with <u>three</u> clips?

_______ 7. Does the outside of the can contain the following information: "This Side Up", DOT hazard class label, laboratory address and traffic number?

_______ 8. Has the proper cushioning material (ie-vermiculite) been used for sample packaging?

_______ 9. Has the correct proper shipping name and hazard class been selected for each sample being shipped?

_______ 10. Is each cooler drain taped shut?

_______ 11. Have all coolers been labeled with the <u>proper</u> laboratory address and has this label been covered with clear tape?

_______ 12. Does each cooler contain samples of only one hazard class?

_______ 13. Have all coolers been labeled and marked as required by DOT Regulations for that particular hazard class?

________ 14. Have all coolers been marked with the appropriate UN Number?

________ 15. Is there at least one Chain-Of-Custody record per cooler?

________ 16. Have the proper sections of the sampling paperwork been put in a plastic bag and taped to the inside lid of the cooler?

________ 17. Has each cooler been secured properly with strapping tape?

________ 18. Have numbered custody seals been affixed to the front right and back left of each cooler and covered with clear tape?

________ 19. Has the shipper completed a hazardous material certification form for each hazard class being shipped?

________ 20. Has the sampler double-checked all paperwork and packaging procedures for accuracy and completeness immediately prior to strapping each cooler for shipment?

________ 21. Have photos of each cooler, showing custody seals and proper packaging procedures, been taken?

I certify that all the above procedures have been followed and that all coolers have been properly packaged for shipment.

X ____________________ Sampler Signature

X ____________________ Team Leader Signature

NOTE: If there is any question that one of the above has been done incorrectly by any member of your team, DO NOT ship samples without checking your suspicions (Even if this means re-opening coolers that have already been strapped shut!)

45T:6M

PART 173—SHIPPERS—GENERAL REQUIREMENTS FOR SHIPMENTS AND PACKAGINGS

SUBPART A

GENERAL

§ 173.1 Purpose and scope. (a) This part defines hazardous materials for transportation purposes and prescribes certain requirements to be observed in preparing them for shipment by air, highway, rail, or water, or any combination thereof.

(b) A shipment that is not prepared for shipment in accordance with this subchapter may not be offered for transportation by air, highway, rail, or water. It is the duty of each person who offers hazardous materials for transportation to instruct each of his officers, agents, and employees having any responsibility for preparing hazardous materials for shipment as to applicable regulations in this subchapter.

(c) When a person other than the person preparing a hazardous material for shipment performs a function required by this part, that person shall perform the function in accordance with this part.

§ 173.2 Classification of material. (a) *Classification of material having more than one hazard as defined in this part.* Except as provided in paragraph (b) of this section, a hazardous material, having more than one hazard as defined in this Part, must be classed according to the following order of hazards:

(1) Radioactive material.
(2) Poison A.
(3) Flammable gas.
(4) Non-flammable gas.
(5) Flammable liquid.
(6) Oxidizer.
(7) Flammable solid.
(8) Corrosive material (liquid).
(9) Poison B.
(10) Corrosive material (solid).
(11) Irritating materials.
(12) Combustible liquid (in containers having capacities exceeding 110 gallons).
(13) ORM-B.
(14) ORM-A.
(15) Combustible liquid (in containers having capacities of 110 gallons or less).
(16) ORM-E.

(b) **Exceptions.** Paragraph (a) of this section does not apply to—

(1) a material specifically identified in § 172.101 of this subchapter,

(2) An explosive required to be classed and approved under § 173.86, or a blasting agent required to be classed and approved under § 173.114a

(3) An etiologic agent identified in § 173.386 as those materials listed in 42 CFR 72.25(c), or

(4) An organic peroxide (See § 172.101 and 173.151a of this subchapter.)

§ 173.3 Packaging and exceptions. (a) The packaging of hazardous materials for transportation by air, highway, rail, or water must be as specified in this part. Methods of manufacture, packing, and storage of hazardous materials, that affect safety in transportation, must be open to inspection by a duly authorized representative of the initial carrier or a representative of the Department. Methods of manufacture and related functions necessary for completion of a DOT specification packaging must be open to inspection by a representative of the Department.

(b) The regulations setting forth packaging requirements for a specific material apply to all modes of transportation unless otherwise stated, or unless exceptions from packaging requirements are authorized. For example, the restriction in § 173.249(b) applicable to cargo-only aircraft applies only to quantities in excess of those allowable under § 173.244. Quantities covered under § 173.244 may also be shipped by cargo-only aircraft.

(c) Packages of hazardous materials that are damaged or found leaking, and hazardous materials that have been spilled or leaked may be placed in a metal removable head salvage drum that is compatible with the lading and shipped for repackaging or disposal under the following conditions:

(1) The drum utilized may be either a DOT specification or a non-DOT specification drum as long as the drum has equal or greater structural integrity than a package that is authorized for the respective material in this subchapter. Maximum capacity shall not exceed 110 gallons.

(2) Each drum must be provided with adequate closure and when necessary, provided with sufficient cushioning and absorption material to prevent excessive movement of the damaged package and to absorb all free liquid. All cushioning and absorbent material used in the drum must be compatible with the hazardous material.

(3) Each drum must be marked with the proper shipping name of the material inside the defective packaging and the name and address of the consignee. In addition, the drum must be marked "SALVAGE DRUM".

(4) Each drum must be labeled as prescribed for the respective material.

(5) The shipper shall prepare shipping papers in accordance with Subpart C of Part 172 of this subchapter.

(6) The overpack requirements of § 173.25, and the reuse provisions of § 173.28(h) and § 173.28(m) do not apply to drums used in accordance with this paragraph.

§§ 173.4—173.5 [Reserved]

§ 173.6 Shipments by air. (a) **General shipping requirements.** When the regulations indicate a hazardous material is forbidden aboard cargo-only aircraft, the material is also forbidden aboard passenger-carrying aircraft.

(b) **General packaging requirements.** (1) In addition to the requirements of this part and Parts 175 and 178 of this subchapter, for air shipments each packaging must be designed and constructed to prevent leakage that may be caused by changes in altitude and temperature during air transportation.

(2) Inner containers that are breakable (such as earthenware, glass, or brittle plastic), must be packaged to prevent breakage and leakage under conditions normally incident to transportation. These completed packagings must be capable of withstanding a 4-foot drop on solid concrete in the position most likely to cause damage. Cushioning and absorbent materials must not be capable of reacting dangerously with the contents. Where any plastic packaging is specified in this part, a plastic bag or pouch is not permitted unless specifically authorized.

(3) For any packaging with a capacity of 110 gallons or less containing liquid, sufficient outage (ullage) must be provided to prevent liquid contents from completely filling the packaging at 130° F. The primary packaging (which may include composite packaging), for which retention of the liquid is the basic function, must be capable of withstanding without leakage, an internal absolute pressure of no less than 26 lbs./sq. inch or no less than the sum of the absolute vapor pressure of the contents at 130°F. (55°C.) and the atmospheric pressure at sea level, whichever is greater.

(4) Stoppers, corks, or other such friction-type closures must be held securely, tightly, and effectively in place with wire, tape, or other positive means. Each screw-type closure on any inside plastic packaging must be secured to prevent the closure from loosening due to vibration or substantial changes in temperature.

(5) Bags permitted by regulations as outside packaging for transportation aboard aircraft must be water resistant.

(6) For any cylinder containing hazardous materials incorporating valves, sufficient protection must be provided to prevent operation and damage to such valves during transportation, by one of the following methods:

(i) By equipping each cylinder with securely attached valve caps or protective headrings, or

(ii) By boxing or crating of the cylinder.

(7) Tank cars and tank motor vehicles containing hazardous materials may not be transported aboard aircraft.

(c) **Special labeling requirements.** See "Magnetized materials" in §§ 172.101 and 173.1020 of this subchapter and see § 172.101 for cargo-only aircraft labeling requirements.

§ 173.7 U.S. Government material. (a) Shipments of hazardous materials offered by or consigned to the Department of Defense (DOD) of the U.S. Government must be packaged, including limitations of weight, in accordance with the regulations in this subchapter or in containers of equal or greater strength and efficiency as required by

CHAPTER 15
CHAIN OF CUSTODY

15.1 INTRODUCTION

An unbroken chain of sample custody both in the field and the laboratory is necessary to ensure that no one has tampered with the samples--an important consideration in legal proceedings. The following chain-of-custody procedure is adapted from the procedures of EPA's National Enforcement Investigations Center (NEIC, April, 1984).

After collection and identification, the samples are maintained under the chain-of-custody procedures. If the sample collected is to be split with the owner or operator of the site or other regulatory agencies, it should be aliquoted into similar sample containers.

Each person involved with the sample must know chain-of-custody procedures, which should be included in the project work plan or be published and available to all personnel. Because samples can serve as legal evidence, the possession of samples must be traceable from the time they are collected until they are introduced in legal proceedings. Chain-of-custody procedures are summarized below.

15.2 Sample Custody

A sample is under custody if:

(a) it is in your actual possession, or
(b) it is in your view, after being in your physical possession, or
(c) it was in your physical possession and then locked up to prevent tampering, or
(d) it is in a designated and identified secure area.

(2) Field Custody Procedures

(a) When collecting samples for evidence, collect only that number which provides a good representation of the media being sampled. To the extent possible, the quantity and types of samples and sample locations are determined prior to the actual field work. As few people as possible should handle the samples.

(b) The field sampler is personally responsible for the care and custody of the samples until they are transferred or properly dispatched.

(c) Sample tags are to be completed for each sample using waterproof ink unless prohibited by weather conditions. For example, a logbook notation would explain that a pencil was used to fill out the sample tag because the ballpoint would not function in freezing weather.

(d) The project coordinator must review all field activities to determine whether proper custody procedures were followed during the field work and decide if additional samples are required. He or she should notify the EPA Project Officer of a breach or irregularity in chain of custody procedures.

15.3 Transfer of Custody and Shipment

(a) Samples are accompanied by a chain-of-custody record. (See Appendix 14-A) When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.

(b) Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in each sample box or cooler. Shipping containers will be locked and secured with strapping tape and EPA custody seals for shipment to the laboratory. Photographs are also taken of the open cooler showing contents prior to shipment and of the closed, strapped and sealed cooler ready for shipment. Preferred procedure includes use of a custody seals attached to the front right and back left of the cooler. The custody seals are covered with clear plastic tape. The cooler is strapped shut with strapping tape in at least two locations.

(c) Whenever samples are split with a source or government agency, a separate Sample Receipt is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the facility or agency should request the representative's signature acknowledging sample receipt. If the representative is unavailable or refuses, this is noted in the "received by" space.

(d) All shipments will be accompanied by the Chain of Custody Record identifying the contents. The original record will accompany the shipment, and the pink and yellow copies will be retained by the sampler for return to the FIT office.

(e) If the samples are sent by common carrier, a bill of lading should be used. Receipts of bills of lading will be retained as part of the permanent documentation. If sent by mail, the package will be registered with return receipt requested.

CHAPTER 16
MONITORING WELL INSTALLATION/GROUNDWATER STUDIES

16.1 INTRODUCTION

This chapter presents guidelines for the installation of groundwater monitoring wells for FIT activities in Region V. The necessity of monitoring well installation occurs in one of two ways:

- o a special Technical Directive Document (TDD) requiring well installation issued by U.S. EPA, or
- o a determination is made during SI work plan preparation that well installation will likely result in an increase in the HRS score to 28.5 or greater through identification of contamination.

Once the need for monitoring well installation has been established a sequence of five steps must follow to insure successful completion of the monitoring well installation/groundwater study. The five steps and their subsection within this chapter are:

- o Background Investigation (16.2),
- o Drilling Proposal (16.3),
- o Request for Bid/Drilling Subcontractor Selection (16.4),
- o Field Activities (16.5), and
- o Hydrogeologic Report (16.6).

16.2 BACKGROUND INVESTIGATION

A complete background investigation designed to confirm the need for monitoring well installation, identify monitoring well installation locations, and assure the safety of FIT employees is essential to successful completion of all monitoring well installation/groundwater study programs. Region V FIT geotechnical staff must address the following areas during the background investigation:

- File Review,
- Additional Information Acquisition,
- Site Safety Plan,
- Site Inspection,
- Geophysical Needs Assessment, and
- Monitoring Well Needs Review and Work Plant Preparation.

16.2.1 File Review

A file review will be completed by a geotechnical staff member when a site potentially requiring monitoring well installation is identified. The geotechnical manager will assign the specific sites to staff members. The file review will include the following:

- a check of the preliminary HRS score verifying the need for installation of monitoring wells,

- a review of site history with emphasis on waste characterization,

- an identification of the expected safety level required for future activities,

- acquisition of available information regarding geography, geology and hydrogeology of site (including water use), and

- a determination of the need for additional information acquisition.

16.2.2 Additional Information Acquisition

If additional information is required to adequately plan and prepare for a monitoring well installation/groundwater study, FIT personnel will acquire the necessary information. Sources may include current or previous site owners and/or operators and local, county, regional, state or federal agencies. Appendix 16-A is a directory of databases available for U.S. EPA Region V.

16.2.3 Site Safety Plan

A site safety plan must be prepared prior to an on-site field inspection. Chapter 3 details preparation of the site safety plan.

16.2.4 Site Inspection

An on-site field inspection fulfills U.S. EPA requirements for completion of HRS scoring and provides FIT with the information necessary to properly select monitoring well installation locations and successfully complete a groundwater investigation.

Information which FIT personnel should determine during the site inspection should include as a minimum the following:

- evidence of disposal practices which may affect monitoring well locations,

- evidence of waste disposal practices which may necessitate the application of geophysical techniques,

- drilling vehicle access,

- special hazards (i.e., high power lines or buried utilities),

- type of terrain,

- landowner information for property/ies where monitoring well installation is proposed (permission to drill can be secured at this time), and

- maps, aerial photos, well logs or other information.

16.2.5 Need for Geophysical Work

The need for geophysical investigation of the site should be evaluated with the geotechnical manager(s) to determine if existing site information regarding buried metal objects, geology, and contaminant migration is sufficient to safely and properly install the monitoring wells. The uses and limitations of geophysics as a tool are discussed in a separate SOP.

16.2.6 Monitoring Well Needs Review and Work Plan Preparation

Following the site inspection, FIT personnel including the geotechnical manager(s) will review available information to evaluate: whether the need for monitoring well installation exists; whether there is a need for geophysical investigation; and the proposed locations, depths and construction for any monitoring wells. FIT's evaluation will be reviewed with the U.S. EPA RPO and a decision to proceed or discontinue geophysical/monitoring well installation work would be finalized.

16.3 DRILLING PROPOSAL

Following approval of monitoring well installation, a drilling proposal must be completed by a geotechnical staff member.

staff member. The drilling proposal will include:

A. INTRODUCTION

1. Purpose for Drilling and Objectives (special TDD or site inspection and data acquisition objectives)

2. Site Location Information with Map

3. Number of Proposed wells (see D.1 below)

4. Preferred Drilling Technique (see D.3 below)

5. Other Information as Necessary

B. BACKGROUND

1. Site History (from file review)

2. Waste Characterization (from file review)

3. Sampling history/results (from file review)

C. SITE CHARACTERISTICS

1. Site Geography (from site inspection)

   a. Type of Terrain
   b. Type of Vegetation
   c. Other Important Features/Hazards

2. Site Geology (from file or additional information - Appendix 16-A).

3. Site Hydrology (from file, site inspection or additional information - Appendix 16-A).

   a. Surface water
      1) Nearby surface water bodies
      2) Site drainage

   b. Groundwater
      1) Aquifer(s) of concern - include water usage
      2) Aquifer(s) characteristics

D. MONITORING WELL INSTALLATION

1. Total number and type of wells to be installed, location map and estimate of total footage (see Appendix 16-B)

2. Mobilization information (terrain, vegetation from site inspection) safety equipment

3. Type of drilling technique (see Appendix 16-C and appropriate state requirements)

4. Type and number of subsurface soil samples to be obtained - includes bedrock coring. (see Appendix 16-D.)

5. Estimate of difficult moving problems due to terrain/vegetation

6. Type and total footage of well materials (selection of well materials based on state requirements and/or Procedures Manual for Groundwater Monitoring at Solid Facilities (EPA, 1977), or Ground Water and Wells (Johnson, 1975), and Handbook for Sampling and Sample Preservation of Water and Wastewater (EPA, 1982)

7. Type, number, and length and slot size of well screens (see D.6 above)

8. Well Development Techniques (see Appendix 16-E)

9. Information regarding containerization and disposal of potentially hazardous materials generated during monitoring well installation - determination made by HNU, OVA or similar field instrument (see Appendix 16-F plus appropriate U.S. EPA regulations)

10. Safety requirements and provisions

16.4 REQUEST FOR BIDS (RFB)/DRILLING SUBCONTRACTOR SELECTION

Following approval of the drilling proposal by the geotechnical manager(s), a RFB will be prepared by the geotechnical staff. This document will contain all background information and technical specifications necessary for a potential subcontractor to submit a competitive bid for the required geotechnical work. The bulk of the information presented in the RFB should be readily transferrable from the drilling proposal.

The completed RFB, with cover letter, will be sent to several drilling firms selected from a list of potential bidders maintained by the Geotechnical Manager. Dates for submittal of the bid packages and tentative commencement of drilling activities are also set by the Geotechnical Manager.

Shortly after the deadline for bid submittal, a winning bid will be selected by the Geotechnical Manager. Selection of the winning bid will be based upon a careful review of the lowest bids for technical compliance with specifications and ability to conform to schedules and U.S. EPA policies. Following notification of the successful bidder, the subcontract package will be prepared by the geotechnical staff under the guidance of the manager. Approval of of the successful bidder and award of the subcontact is handled through E & E in Washington D.C. All subcontracts are approved by U.S. EPA headquarters.

16.5 FIELD ACTIVITIES

Field activities subsequent to subcontractor selection are discussed in this section. Field activities included in discussion are monitor well installation and aquifer tests for physical characteristics. Aquifer sampling for chemical characteristics is discussed in Chapter 7.

16.5.1 Monitor Well Drilling

Monitor well drilling activities require some office work prior to field mobilization. Before any well is begun, the geotechnical staff member must insure that permission to drill from appropriate landowners has been obtained. The geotechnical staff member must also coordinate all work with the drilling company. Clearance of underground utilities is the responsibility of the drilling company. The geotechnical staff member should insure that the drilling company has contacted appropriate underground utility companies prior to any drilling activities. As a minimum, the following items are required for a drilling job:

site safety plan,
proper safety equipment,
hard hat,
steel toe shoes/boots,
appropriate gloves,
steel tape,
engineers folding ruler,
blank drilling log forms,
locks and keys, and
copy of subcontract agreement.

Upon arrival at the site on the first day of drilling, the geotechnical staff member will:

- inspect drilling rig(s) for cleanliness and assure that there are no excessive oil or hydraulic fluid leaks;

- conduct a safety briefing for drillers and have the sign-off sheet completed after the briefing;

- verify that the drillers have appropriate safety equipment and forms;

- remind drillers that the use of petroleum based lubricants on external parts used in drilling is not allowed; and

- establish an area to be used for decontamination of drilling equipment.

Unless circumstances prohibit, upgradient wells will be installed first. The following duties will be performed by the geotechnical staff member during monitoring well installation:

- monitor boring hole and cuttings with HNU, OVA or other appropriate instrument. The purposes of monitoring are personnel safety (refer to safety plan for action levels) and detection of contaminated wastes for proper disposal;

- monitor subcontractor performance for adherence to the procedures outlined in the approved subcontract;

- maintain time and footage log for all subcontract pay items (should be reviewed daily with driller);

- classify drilling cuttings as to physical properties as outlined in <u>Guidelines for Classifying and Describing Soil and Rock Samples</u> and maintain a monitor well boring log;

- collect samples for chemical analysis (if required); and

- provide technical guidance to driller during all phases of operations.

Upon completion of each monitoring well the geotechnical staff member will:

- assure proper development of well screen is accomplished (no sooner than 48 hours after drilling), and

- provide lock to be installed on protective outer casing.

The geotechnical staff member is responsible for telephoning the geotechnical manager daily to report progress, delays or problems.

16.5.2 Physical Measurements and Aquifer Tests for Physical Characteristics

Physical measurements and aquifer tests for physical characteristics are a necessary part of any hydrogeologic study. As a minimum the following must be completed:

- well locations will be accurately plotted on an appropriate scale map,

- well elevations will be surveyed,

- water level measurements will be obtained, and

- aquifer hydraulic conductivity testing will be conducted.

16.5.2.1 Location of Wells

Proper location of monitoring wells on maps is necessary for development of geologic cross-sections, preparation of potentiometric surface maps, determination of horizontal hydraulic gradients and other purposes.

Accurate location of monitoring wells on an appropriate scale map will be accomplished in one of three ways which are:

- location on aerial photograph,

- field measurements with cloth tape from landmarks identifiable on aerial photograph or map, and

- surveying (see next paragraph for accuracy requirement).

16.5.2.2 Surveying of Wells

Surveying of wells will include both ground and top of inner well casing measurements. Requirements for surveying will meet the following guidelines:

> Excellent leveling for important city bench marks, or for the principal bench marks on extensive surveys. Sights up to 300 ft. in length. Rod readings to thousandths of feet with either the target rod or the self-reading rod. Backsight and foresight distances measured by pacing and approximately balanced between bench marks. Rod waved for large rod readings. Bubble carefully centered before each sight. Turning points on metal pin or plate, or on well-defined points of solid objects. Tripod set on firm ground. Maximum allowable error, in feet, is $\pm$ 0.05 $\sqrt{\text{miles}}$.

Measurements should be referenced to USGS or local bench mark whenever possible. Temporary reference elevations are acceptable where benchmark use is impractical. The water surface of nearby water bodies should be included in the survey for comparison with groundwater elevations.

16.5.2.3 Water Levels

Accurate water level measurements are an integral part of all groundwater studies. At least one set of measurements is required although additional measurements at various times throughout the year will yield a better picture of the groundwater system. Groundwater monitor wells will be compared with nearby surface water elevations as noted in 16.5.2.2. Measurements of groundwater and surface water elevations must be accomplished on the same day. Comparison of measurements for different days is unacceptable.

The following procedures will be followed to assure accurate water level measurements:

> The static water level and the total well depth should be determined with 1) chalked (blue carpenter's chalk), stainless steel tape), 2) stainless steel tape and popper, or 3) electric sounder (sometimes referred to as an electric tape). Each device should be slowly lowered into the water to prevent splashing. The advantage of a steel tape over the electric sounder is the ability to measure water levels more accurately (i.e., within 0.01 foot). However, compared to the electric sounder, the steel tape has the disadvantage that if the approximate depth to water is unknown it may be necessary to lower the tape into the well several times before obtaining a reliable reading. In addition, water on the casing wall may wet the steel tape above the true water level, resulting in measurement errors. Where a series of measurements are necessary in quick succession, such as in pumping tests, electric sounders have the advantage of not having to be removed from the well between each reading. Decontamination of tapes and sounders is generally accomplished with a distilled water rinse and drying with disposable paper towels. In some cases, the tape may be decontaminated with a solvent (e.g., acetone), but the use of solvents on the electric sounder is discouraged due to the possible adverse effects on wires and the probe. The

point of reference (i.e., measuring point on well casing), the depth to water, and the time should be recorded for every measurement.

16.5.2.4 Aquifer Hydraulic Conductivity Test

The hydraulic conductivity of the aquifer must be determined for the screened portion of all monitoring wells installed for Region V FIT activities. It is possible to determine in-situ hydraulic conductivity values by means of tests carried out in a single piezometer. There are two such tests, one suitable for point piezometers that are open only over a short interval at their base, and one suitable for screened or slotted piezometers that are open over the entire thickness of a confined aquifer. Both tests are initiated by causing an instantaneous change in the water level in a piezometer through a sudden introduction or removal of a known volume of water. The recovery of the water level with time is then observed. When the water is removed, the tests are often called bail tests; when it is added, they are known as slug tests. It is also possible to create the same effect by suddenly introducing or removing a solid cylinder of known volume. Region V FIT uses the solid cylinder technique to perform aquifer slug tests. Instantaneous water level readings are obtained with an IN-SITU SE1000 pressure transducer unit. Before use, the geotechnical staff member will review the SE1000 operations manual which is kept with the unit.

The method of interpreting the water level versus time data that arise from bail tests or slug tests depends upon which of the two test configurations is felt to be most representative. The method of Hvorslev (1951) is for a point piezometer, while that of Cooper et al., (1967) is for a confined aquifer. FIT currently has operational computer models for interpretation of data for either of the above test configurations.

APPENDIX 16-A

DIRECTORY OF ENVIRONMENTAL DATA BASES

FOR

ILLINOIS, INDIANA, MICHIGAN, MINNESOTA, OHIO, AND WISCONSIN

DIRECTORY OF ENVIRONMENTAL DATABASES
FOR
ILLINOIS, INDIANA, MICHIGAN, MINNESOTA, OHIO AND WISCONSIN

PREPARED BY:

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 South Dearborn Street
Chicago, Illinois 60604

TABLE OF CONTENTS

INTRODUCTION

This directory presents national, regional, state, and local sources of environmental and socioeconmic baseline information covering the states in US Environmental Protection Agency (EPA) Region V (Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin). The directory is intended to provide EPA, State agency and local officials involved in the environmental review of wastewater treatment projects under EPA's Construction Grants Program with information concerning data sources that can be used to assist in the development of environmental impact statements (EISs), assessments (EAs), or information documents (EIDs). The information presented in this directory also is intended to be useful for other programs carried out by EPA Region V and the various State agencies in the six States by describing data sources that cover a variety of topical areas and which can be utilized in a number of different ways. As a reference tool, this directory summarizes and highlights the primary data sources that are typically used to prepare environmental assessment documents, including EISs, EAs and EIDs. This directory also is intended, in some instances, to provide guidance as to the type of information that should be included in such documents, although the level of detail required in a particular environmental assessment document will vary depending on the nature of the project under examination and the type of document being prepared, i.e., EIS, EA or EID.

The organization of this directory reflects the categories addressed in environmental impact statements (EISs) prepared under the National Environmental Policy Act (NEPA):

- Earth resources and atmosphere (topography, geology, soils, prime and unique agricultural lands, air quality, climate)
- Water resources (surface water and groundwater hydrology, quality and use; flood hazard areas)
- Biological resources (aquatic biology, wildlife, wetlands, forests, endangered species)
- Socioeconomics (population, housing, land use, community finances)

- Historical and archaeological resources.

In each of the above categories, data sources and descriptions are given first on national and regional levels, and then separately for each state and other local sources. Preceeding the categorized sources is a section detailing more broadly-based information sources which includes major reference libraries and computerized databases.

I. GENERAL DATA SOURCES

A. STATE LIBRARIES, EPA REGION V LIBRARY, AND MAJOR REFERENCE LIBRARIES

State Libraries act as depositories of federal government publications, state legislative information and regulations, historical records, and data on localities within the state. State librarians also provide valuable guidance by alerting individuals to other sources of needed data. Major reference libraries in communities throughout each state are also useful sources of site-specific data. The majority of these libraries provide on-line searching of computerized bibliographic databases, and share the facilities of other libraries through regional reference and information networks.

The EPA Region V Library, with offices in Chicago, was formed in 1971 to cover environmental subject areas in the six States of Region V as well as the Great Lakes Basin, Ohio River Basin, and the Upper Mississippi River Basin. Listed below are the general categories of materials available:

- Legal (includes the U.S. Code, Public Laws, Code of Federal Regulations, EPA Legal Compilations, Congressional/Legislative materials, and State Laws)
- Technical Reports and Documents (includes EPA reports, Environmental Impact Statements, Nuclear Plan Reports, and Air Pollution Technical Information Center materials)
- Reference materials
- Journals (approximately 400 listings)
- Books (approximately 2,500 titles)

The Region V Library shares resources with many libraries and other EPA facilities through its interlibrary loan program. The library's address is:

US Environmental Protection Agency
Region V Library
230 S. Dearborn St.
Chicago, IL 60604
312/353-2022

In the following pages, a list of State Libraries is presented, followed by listings of major reference libraries in each state. In the state lists, the libraries in the left-hand columns are those which function as depositories for geological and water-resources publications and maps issued by the U.S. Geological Survey (USGS); those in the right-hand columns are depositories of materials issued by Federal departments and agencies and published by the Government Printing Office (GPO). Libraries with asterisks in the left-hand columns are both USGS and GPO depositories; and those with double asterisks are GPO Regional Depositories, which are required to retain copies of all government publications.

STATE LIBRARIES

ILLINOIS STATE LIBRARY

Office of the Secretary of State
273 Centennial Bldg.
Springfield, IL 62704
217/782-2994

INDIANA STATE LIBRARY

140 N. Senate Ave.
Indianapolis, IN 46204
317/232-3678

MICHIGAN STATE LIBRARY

Law Bldg., 1st. Floor
525 W. Ottawa St.
Lansing, MI 48913
517/373-0640

WISCONSIN STATE LIBRARY

310 E. State Capitol
Madison, WI 53702
608/266-1600

MINNESOTA STATE LIBRARY

117 University Avenue
St. Paul, MN 55155
612/296-2775

OHIO STATE LIBRARY

Ohio Departments Bldg.
65 S. Front St.
Columbus, OH 43215
614/462-7061

MAJOR REFERENCE LIBRARIES IN ILLINOIS

U.S. Geological Survey Depositories

Aurora
  Public Library
Carbondale
  Southern Illinois University*
Charleston
  Eastern Illinois University*
Chicago
  Chicago Academy of Science
  Field Museum of Natural History
  John Crerar Library*
  Loyola University*
  Museum of Science and Industry
  Chicago Public Library*
  University of Chicago*
  University of Illinois
De Kalb
  Northern Illinois University*
Edwardsville
  Southern Illinois University*
Elgin
  Gail Borden Public Library
Elsah
  Principia College*
Evanston
  Northwestern University*
Galesburg
  Knox College
Kankakee
  Olivet Nazarene College*
Macomb
  Western Illinois University*
Monmouth
  Monmouth College*
Normal
  Illinois State University*
Peoria
  Peoria Public Library*
Rock Island
  Augustana College
South Holland
  South Holland Library
Springfield
  Illinois State University**
Urbana
  Illinois Geological Survey
  University of Illinois*

U.S. Government Printing Office Depositories

Bloomington
  Illinois Wesleyan University
Carlinville
  Blackburn College
Carterville
  Shawnee Library System
Champaign
  University of Illinois
Chicago
  Chicago State University
  DePaul University School of Law
  Field Museum of Natural History
  Illinois Institute of Technology
  Loyola University School of Law
  Northeastern Illinois University
  Northwestern University School of Law
  University of Illinois at Chicago Circle
  William J. Campbell Library of the U.S. Courts
Decatur
  Decatur Public Library
Edwardsville
  Southern Illinois University
Freeport
  Freeport Public Library
Galesburg
  Galesburg Public Library
Glen Ellyn
  Lewis University College of Law
Jacksonville
  MacMurray College
Lake Forest
  Lake Forest College
Lebanon
  Mckendree College
Lisle
  Illinois Benedictine College
Lockport
  Lewis University
Moline
  Black Hawk College
Morton Grove
  Oakton Community College
Mount Carmel
  Black Hawk College
Morton Grove
  Oakton Community College
Mount Carmel
  Wabash Valley College

* Also a GPO Depository.
** GPO Regional Depository.

U.S. Government Printing Office Depositories

Mount Prospect
  Mount Prospect Public Library
Oak Park
  Oak Park Public Library
Oglesby
  Illinois Valley Community College
Palos Hills
  Moraine Valley Community College
Park Forest South
  Governors' State University
Peoria
  Bradley University
River Forest
  Rosary College
Rockford
  Rockford Public Library
Wheaton
  Wheaton College
Woodstock
  Woodstock Public Library

MAJOR REFERENCE LIBRARIES IN INDIANA

U.S. Geological Survey Depositories

Bloomington
  Indiana University*
Fort Wayne
  Indiana-Purdue Universities*
Gary
  Indiana University*
Greencastle
  De Pauw University*
Hanover
  Hanover College*
Indianapolis
  Indiana State Library**
  Indiana-Purdue Universities
Muncie
  Ball State University*
New Albany
  Indiana University Southeast*
Notre Dame
  University of Notre Dame*
Rensselaer
  St. Joseph's College*
Richmond
  Earlham College*
Terre Haute
  Indiana State University*
Valparaiso
  Valparaiso University*
West Lafayette
  IndianaPurdue Universities

U.S. Government Printing Office Depositories

Anderson College
  Anderson College
Crawfordsville
  Wabash College
Evansville and Vanderburgh County
  Public Library
Ft. Wayne
  Public Library of Ft. Wayne & Allen
    County
Franklin
  Franklin College Library
Greencastle
  De Pauw University
Hammond
  Hammond Public Library
Huntington
  Huntington College
Indianapolis
  Butler University
  Indianapolis-Marion County Public
   Library
  Indiana University Law School
  Indiana Supreme Court Law Library
Kokomo
  Indiana University Regional Library
Lafayette
  Purdue University
Muncie
  Muncie Public Library
Richmond
  Morrison-Reeves Library
South Bend
  Indiana University
Valparaiso
  Valparaiso University School of Law

---

* Also a GPO Depository.
** GPO Regional Depository.

MAJOR REFERENCE LIBRARIES IN MICHIGAN

U.S. Geological Survey Depositories

Albion
  Albion College*
Allendale
  Grand Valley State College*
Alma
  Alma College*
Ann Arbor
  Great Lakes Basin Commission*
  University of Michigan*
Berrien Springs
  Andrews University
Bloomfield Hills
  Cranbrook Insitute of Science*
Detroit
  Detroit Public Library
  University of Detroit*
  Wayne State University*
Dowagiac
  Southwestern Michigan College*
East Lansing
  Michigan State University*
Escanaba
  Michigan State Library*
Farmington
  Oakland Community College*
Flint
  Charles Steward Mott Library
  Flint Public Library*
Grand Rapids
  Calvin College Library*
  Knollcrest Calvin Library
  Grand Rapids Public Library*
Houghton
  Michigan Technological University*
Ishpeming
  Lake Superior Mining Institute
Kalamazoo
  Western Michigan University*
Lansing
  Geological Survey, Department
    of Conservation
  Michigan State Library**
Livonia
  Schoolcraft College

* Also a GPO Depository.
** GPO Regional Depository.

U.S. Government Printing Office Depositories

Ann Arbor
  University of Michigan
  University of Michigan School of Law
Benton Harbor
  Benton Harbor Public Library
Dearborn
  Henry Ford Centennial Library
  Henry Ford Community College
Detroit
  Detroit College of Law
  Marygrove College
  Mercy College of Detroit
  University of Detroit
  University of Detroit School of Law
  Wayne State
Jackson
  Jackson Public Library
Kalamazoo
  Kalamazoo Public Library
Lansing
  Thomas M. Cooley Law School
Livonia
  Schoolcraft College
Marquette
  Northern Michigan University
Mt. Clemens
  Macomb County Library
Olivet
  Olivet College Library
Petoskey
  North Central Michigan College
Port Huron
  St. Clair County Library
Rochester
  University Center
  Delta College Library
Warren
  Warren Public Library
Wayne
  Wayne Oakland Federated Library System

U.S. Geological Survey Depositories

Monroe
  Monroe County Library System*
Mt. Pleasant
  Central Michigan University*
Muskegon
  Hackley Public Library*
Rochester
  Oakland University*
Saginaw
  Hoyt Public Library*
Traverse City
  Northwestern Michigan College*
Ypsilanti
  Eastern Michigan University*

* Also a GPO Depository.
** GPO Regional Depository.

MAJOR REFERENCE LIBRARIES IN MINNESOTA

U.S. Geological Survey Depositories

Bemidji
  Bemidji State College*
Collegeville
  St. Johns University*
Duluth
  Duluth Public Library*
  University of Minnesota
Mankato
  Mankato State College*
Minneapolis
  Hennepin County Library*
  Minneapolis Public Library*
  St. Anthony Falls Hydraulic Lab.
  University of Minnesota, Wilson Library**
  University of Minnesota, Winchell Library
Moorhead
  Moorhead State College*
Northfield
  Carleton College*
  St. Olaf College*
St. Cloud
  St. Cloud State College*
St. Paul
  James Jerome Hill Reference Library
  Macalester College Geology Dept. and Library
  Minnesota Geological Survey
  Minnesota Historical Society*
  St. Paul Public Library*
  Science Museum of Minnesota
St. Peter
  Gustavus Adophus College*
Winona
  Winona State University, Maxwell Library*

* Also a GPO Depository.
** A GPO Regional Depository.

U.S. Government Printing Office Depositories

Minneapolis
  Anoka County Library
University of Minnesota School of Law

Morris
  University of Minnesota at Morris
St. Paul
  Hamline University School of Law
  Minnesota State Law Library
  University of Minnesota St. Paul Campus
  William Mitchell College of Law
Stillwater
  Stillwater Public Library
Willmar
  Crow River Regional Library

MAJOR REFERENCE LIBRARIES IN OHIO

U.S. Geological Survey Depositories

Akron
- Akron Summit Public Library*
- University of Akron*

Alliance
- Mt. Union College*

Athens
- Ohio University*

Bowling Green
- Bowling Green State University*

Canton
- Malone College*

Chardon
- Geauga County Public Library*

Chillicothe
- Ohio University-Chillicothe

Cincinnati
- Cincinnati and Hamilton County Public Library*
- University of Cincinnati*

Cleveland
- Case Western Reserve University*
- Cleveland Public Library*
- Cleveland State University*

Columbus
- Capital University*
- Columbus and Franklin Counties Public Library*
- Ohio State Library**
- Ohio State University*

Dayton
- Dayton Museum of Natural History
- Dayton and Montgomery County Public Library*
- University of Dayton*
- Miami-Ohio State University
- Wright State University*

Delaware
- Ohio Wesleyan University*

Elyria
- Elyria Public Library*

Gambier
- Kenyon College*

Granville
- Denison University*

Hiram
- Hiram College*

---

* Also a GPO Depository.
** A GPO Regional Depository.

U.S. Government Printing Office Depositories

Akron
- University of Akron School of Law

Ashland
- Ashland College

Batavia
- University of Cincinnati at Batavia

Bluffton
- Bluffton College

Cincinnati
- University of Cincinnati College of Law

Cleveland
- Case Western Reserve University School of Law
- Cleveland Heights-University Heights Public Library
- Cleveland State University
- John Carroll University
- Municipal Reference Library

Columbus
- Ohio Supreme Court Law Library

Findlay
- Findlay College
- Middletown

Middletown
- Miami University of Middletown

Portsmouth
- Portsmouth Public Library

Rio Grande
- Rio Grande College

Springfield
- Warder Public Library

Steubenville
- College of Steubenville
- Steubenville and Jefferson County Public Library

Tiffin
- Heidelberg College

Westerville
- Otterbein College

U.S. Geological Survey Depositories

Kent
  Kent State University*
Marietta
  Marietta College*
New Concord
  Muskingum College*
Oberlin
  Oberlin College*
Oxford
  Miami University at Oxford*
Springfield
  Springfield Public Library
  Wittenberg University
Toledo
  Toledo-Lucas County Public Library*
  University of Toledo*
Wooster
  College of Wooster*
Yellow Springs
  Antioch College, Dept. of Earth Sciences & Library
Youngstown
  Youngstown and Mahoning County Public Library*
  Youngstown State University*

---

* Also a GPO Depository.
** A GPO Regional Depository.

MAJOR REFERENCE LIBRARIES IN WISCONSIN

U.S. Geological Survey Depositories

Appleton
  Lawrence University*
Beloit
  Beloit College*
Eau Claire
  Wisconsin State University
Green Bay
  University of Wisconsin-Green Bay*
Kenosha
  University of Wisconsin-Parkside
La Crosse
  Wisconsin State University
Madison
  University of Wisconsin-Madison*
Milwaukee
  Milwaukee Public Library**
  University of Wisconsin-Milwaukee*
Oshkosh
  University of Wisconsin-Oshkosh*
Platteville
  University of Wisconsin-Platteville*
Stevens Point
  University of Wisconsin-Stevens Point*

U.S. Government Printing Office Depositories

Eau Claire
  University of Wisconsin-Eau Claire
Fond du Lac
  Foud du Lac Public Library
La Crosse
  La Crosse Public Library
  University of Wisconsin-La Crosse
Madison
  Madison Public Library
  State Historical Society Library**
  Wisconsin State Law Library
Milwaukee
  Alverno College
  Milwaukee County Law Library
  Mt. Mary College
Racine
  Racine Public Library
River Falls
  University of Wisconsin-River Falls
Superior
  Superior Public Library
  University of Wisconsin-Superior
Waukesha
  Waukesha Public Library
Wausau
  Marathon County Public Library
Whitewater
  University of Wisconsin-Whitewater

* Also a GPO Depository.
** A GPO Regional Depository.

B. THE NATIONAL TECHNICAL INFORMATION CENTER (NTIS)

5285 Port Royal Rd.
Springfield, VA 22161
703/487-4600

The National Technical Information Center (NTIS) is an agency of the U.S. Department of Commerce and is the central source for the public sale of U.S. government-sponsored research, development, and engineering reports as well as other publications prepared by national and local government agencies and their contractors or grantees. The core of the NTIS information system is a collection of more than a million different technical reports on completed government research, all permanently available in the form of film, paper, and magnetic tape. Full summaries of current research reports and other specialized information are published regularly by NTIS in a wide variety of formats, including weekly newsletters, a bi-weekly journal, and an annual index.

The NTIS bibliographic database comprises the bibliographic citations or research summaries of the approximately 70,000 technical reports announced annually. This is the machine-readable version of the printed subscription journal, Government Reports Announcements and Index (GRAI). Searches of the NTIS database, as well as the other data bases listed in this section, can be performed at nominal cost in most of the State and major reference libraries. Searches can be conducted for specific information by identifying the author or title and date as well as for a range of information covering a particular topical area by conducting a search covering certain key words associated with the topical area. For example, to obtain information on the effects of onsite wastewater treatment systems on lake water quality, a search could be conducted using key words such as: water quality, onsite systems, septic tanks, lake eutrophication, nutrient dispersion, algal blooms, etc. In addition, NTIS also publishes a weekly "Abstract Newsletter on Environmental Pollution and Control" that provides abstracts on recently published reports in the areas of air pollution, noise pollution, solid wastes, water pollution, pesticides, radiation, environmental health and safety, general environmental topics and recently issued environmental impact statements.

The NTIS maintains a Local Government Credit Plan under which no advance funds are necessary for local governments to obtain credit and immediate shipments of NTIS products and services. Upon receipt of the special credit account application (PR-220, free on request), NTIS will mail a supply of preaddressed order forms bearing a special account number. These forms also will show a "ship to" address if one is required. Subsequently, orders will be processed directly into the NTIS automated system. Although the price of documents obtained from NTIS varies considerably, most NTIS products cost between $7 and $40. In general, the delivery time for material ordered from NTIS is one to two weeks.

C. COMPUTERIZED DATABASES

Directory of Online Databases
Cuadra Associates, Inc.
1523 Sixth Street Suite 12
Santa Monica, CA 90401
(213) 451-0644

The Directory of Online Databases, published quarterly by Cuadra Associates, Inc., is a complete listing of computerized databases available to the general public. The Directory's criteria for inclusion covers databases that are available through international telecommunications networks as well as those that are accessible through online services connected to networks that serve only one country or a limited set of countries. Information on type, subject, producer, special use conditions, content, coverage and updates is included for each database. The following list of databases is arranged by subject matter. Forty eight of the seventy three listed databases are comprised of citations, and sometimes, summaries of information. The remaining databases contain source data and are preceded by an "(s)" (for source).

Broadly-based data sources:

ASI (American Statistics Index)
Books in Print
Compendex (Computerized Engineering Index)
Comprehensive Dissertation Index
Conference Papers Index
CRIS (Current Research Information System)

Federal Index (Index to Congressional Record, Federal Register, Weekly
Compilation of Presidential Documents, and the Washington Post)
Federal-State Reports Legislative Tracking System
GPO Monthly Catalog
GPO Publications Reference File
ISI/ISTP&B (Index to Scientific & Technical Proceedings & Books)
National Newspaper Index
Newsearch (Citations to current month's magazine, journal and newspaper literature)
NTIS
Research Centers Directory
Scisearch (Citations to worldwide literature covering range of scientific and technologic disciplines)
SSIE (Smithsonian Science Information Exchange)
State Publications
LOGIN (Local Government Information Network)
Research Centers Directory.

Earth Resources and Atmosphere:

APTIC (Air Pollution Technical Information Center)
Geoarchive (Citations to worldwide geoscience literature)
Georef (Citations to geology and geophysics literature)
Meteorological & Geoastrophysical Abstracts
NASA
Oceanic Abstracts (Citations to worldwide literature on oceanography and other marine-related topics)
Range Management (Citations to literature on ranges, pastures, livestock, ranching and wildlife)
(s) Real-Time Weather
(s) Upgrade: SAROAD (Storage and Retrieval of Aerometric Data),
(s) ZIPWTHR NEDS (National Emissions Data System)

Water Resources:

Aqualine (Citations and abstracts on every aspect of water, wastewater, and the aquatic environment)
ASFA (Aquatic Sciences & Fisheries Abstracts)
(s) DMS (Hydrology and water quality data from USGS, NOAA and EPA)
Oceanic Abstracts
Range Mangement
(s) Real-Time Weather
Selected Water Resources Abstracts
(s) WDROP (Water Distribution Register of Organic Pollutants)
(s) UPGRADE: STORET, NASQAN (National Stream Quality Accounting Network)

Biological Resources:

Range Management

Socioeconomics:

(s) American Profile (1980 census data and estimates of current population, households and income)

ASI (American Statistics Index)
(s) Census of Retail Trade
(s) Current Population Survey
(s) EIS Economic Data (400 quarterly time series of national income and product accounts data)
(s) Labor Statistics
(s) National Planning Association/Economic (180,000 annual time series and forecasts of the U.S. economy)
(s) Onsite (aggregate data items from 1970 and 1980 censuses of population and housing)
Population Bibliography
(s) RDA (Regional Data Associates) (housing, demographic, financial and economic data for U.S., States, and SMSAs)
(s) Regional (macroeconomic data for states and SMSAs)
(s) Regional Employment
(s) Regional Forecast (economic projections for states and SMSAs)
(s) Regional Industry (industry specific economic data)
(s) Site 11 (demographic retrieval and report generation system)
(s) U.S. County (employment, personal income and population by county)
U.S. Public Schools Directory
(s) U.S. Regional (regional economic indicators)
(s) Upgrade: IDB (Integrated Database)
(s) Zip Code Demographic Data Base

Archaeological and Historic Resources:

America: History and Life (Citations and abstracts on U.S. and Canadian history, culture, and current affairs)

Agriculture:

AGRICOLA (Citations in agriculture and related areas)
(s) Agriculture (Technical Information Center)
(s) U.S. Census of Agriculture

Environment and Pollution Control:

Electric Power Industry Abstracts
Enviroline (Citations related to the environment and the management and use of natural resources)
Environmental Bibliography
(s) OHM-TADS (Oil and Hazardous Materials Technical Assistance Data System)
(s) Toxicology Data Bank
(s) EDE (Environmental Data and Ecological Parameters)
EIS: Digests of Environmental Impact Statements

D. OTHER SOURCES

- National Referral Center (NRC)

  U.S. Library of Congress
  10 First St., S.E.
  Washington, D.C. 20540
  202/287-5670

The NRC assists persons who need answers to technical questions by referring them to organizations that can provide needed information. This service is based on a computerized, subject-indexed inventory that contains descriptions of specialized information sources in all fields. The NRC responds to inquiries with referrals that include source names, addresses, telephone numbers, and descriptions of services provided. The NRC also publishes periodic directories of information resources. NRC's machine readable files hold information on 13,000 organizations.

- Previous EISs

Valuable site-specific information may be obtained from previous EISs prepared on projects in a particular study area. The EPA Region V Office in Chicago maintains complete EIS files, and can furnish information on whether an EIS has ever been done for a project in a particular study area. The EISs may be examined in the Region V Office, or purchased from Information Resources Press, 1700 N. Moore Street., Arlington, VA 22209 (703/558-8270) in paper or microfilm.

- Community Members and Officials

Extensive information about a project area can be obtained from key members of the community who possess specialized information and knowledge of the area's characteristics and history. Such key informants may be individuals who act in any one of a number of different capacities in the community, of which the following is a partial list:

- Head of local government; mayor; city manager
- Director of planning or individual responsible for planning in the community

- City engineer or director of public works
- Editor of local newspaper, or local reporter for nearby newspaper
- Local banker
- Head of local Board of Education, or school principal
- Local agricultural extension agent
- Representative of the business community
- Faculty members of local colleges or universities
- Other individuals suggested by the above sources.

II. EARTH RESOURCES AND ATMOSPHERE

A. TOPOGRAPHY AND GEOLOGY

1. U.S. Geological Survey

The data and publications of the U.S. Geological Survey (USGS) are extremely productive sources of environmental baseline data regarding an area's topography and geology. The USGS has collected, analyzed, and published detailed information about the nation's mineral, land, and water resources since 1879, and has released this information in a wide variety of available formats, as detailed in this section.

a. Complete Publications Lists -- The USGS has published a complete two-volume listing, with geographical indexes, of all its reports, maps and other publications issued between the years 1879 and 1970. Since 1970, its publications have been indexed in yearly volumes. These indexes are available at no cost. The indexes, and the publications to which they refer, are available as follows:

Text Products and Indexes

U.S. Geological Survey
Text Products Section
Eastern Distribution Branch
604 S. Pickett St.
Alexandria, VA 22302
703/756-6141

Maps of areas east of the Mississippi River, including Minnesota

U.S. Geological Survey
Eastern Distribution Branch
1200 South Eads St.
Arlington, VA 22202
703/557-2751

Maps of areas west of the Mississippi River

U.S. Geological Survey
Western Distribution Branch
Box 25286, Federal Center
Denver, CO 80225
303/234-3832

The USGS supplements its yearly publications listings with a monthly catalog, "New Publications of the Geological Survey." For a free subscription, write:

U.S. Geological Survey
Mailing List Unit
582 National Center
Reston, VA 22092

Literature searches of USGS products can also be conducted online using the GEOREF computerized database. GEOREF also contains earth sciences references from many other sources.

Also available at no cost from the USGS Text Products Section is "A Guide to Obtaining Information from the USGS." This publication is updated annually and contains a complete listing of the types of products available from the USGS, together with detailed access information.

b. Books, Reports, and Periodicals -- These include bulletins, circulars, environmental impact statements, professional papers, and special reports on geological topics, as well as USGS watersupply papers, hydrologic atlases, water resources investigation reports, and other water-related publications.

c. Map Indexes -- These are indispensable for locating needed maps and other materials. Indexes available from USGS include:

- Aerial photography summary record system, by states
- Geological map indexes, by states
- Geophysical index maps, by states
- Index to advance material available from current topographic mapping in progress, by states
- Index to advance material available from the orthophoto mapping program, by states
- Index to aerial photography, by states
- Index to Geological Survey land use and land cover and associated maps

- Index to topographic maps of the U.S., by states
- Status of intermediate-scale county mapping
- Topographic mapping: Status and progress of operations.

d. Maps, Charts, and Diagrams -- the following is partial listing of the types of maps, charts, and diagrams available from the USGS. A full listing is included in the guide referred to on the previous page.

- Geologic quadrangle maps (GQ series)
- Geophysical index maps, by states
- State geologic maps
- Advance material from current topographic mapping
- LANDSAT image maps
- Land use and land cover maps
- National Park maps
- Orthophoto maps
- Out-of-print map reproductions
- Reproducibles of maps and color feature separates
- River survey maps
- Shaded-relief maps
- Slope maps
- State maps: Base, topographic, and relief
- Surface management (land ownership) and surface minerals management (federally-owned mineral rights) maps
- Topographic maps of counties
- Topographic maps of national parks, monuments, and historic sites.

e. Other USGS Data Sources

Sources of additional information within the USGS are given below, together with brief descriptions of the types of data and services provided.

- Public Inquiries Offices
  1028 General Services Administration Bldg.
  19th & F Sts., N.W.
  Washington, D.C. 20244
  202/343-8073

  503 National Center, Rm. 1-C-402
  12202 Sunrise Valley Dr.
  Reston, VA 22092
  703/860-6167

USGS Public Inquiries Offices provide general information about agency programs and publications. Personnel will answer inquiries made in person, by mail, or by telephone; recommend publications relating to specific subjects and areas; and refer requests for specific technical information to the appropriate people. They will also distribute circulars, nontechnical publications, most catalogs, and indexes free of charge.

- Geologic Inquiries Group (GIG)
  907 National Center
  Reston, VA 22092
  703/860-6517

The GIG answers questions on the geology of specific areas, and gives information on geologic maps, mapping, and map indexes. Both written and telephone requests are handled by this office or are referred to the appropriate information source within the USGS.

- National Cartographic Information Center (NCIC)
  507 National Center
  Reston, VA 22092
  703/860-6045

The NCIC is an national information service for U.S. cartographic and geographic data. The NCIC organizes and distributes descriptions of maps and charts; aerial and satellite photographs; satellite imagery, map data in digital form; and geodetic control and geographic data. NCIC also provides ordering assistance for aerial and satellite products available from USGS's EROS Data Center (listed below), and gathers information about aerial photography and mapping projects planned by federal agencies.

The NCIC collects, organizes, and disseminates information on U.S. cartographic products through a central office, 5 federal affiliates, and

23 state affiliates. NCIC provides references, facilities and professional advice on the status and selection of maps, charts, space and aerial photographs, and other cartographic data generated by space and aerial photographs, and other cartographic data generated by government and private agencies; assists users in locating and ordering cartographic products from the USGS; and publishes catalogs and user guides. It maintains the Map and Chart Information System, Aerial Photo Summary Record System, and Cartographic Catalog in machine-readable form. From these systems it provides microform, print, and computer-based services. The NCIC's free quarterly newsletter gives information on new products and materials. Catalogs, user guides, and information brochures are also issued by NCIC. The Map and Chart Information System (MCIS) of the NCIC was constructed from existing computerized files of map descriptions provided by the USGS, the U.S. Defense Mapping Agency, and the Library of Congress. MCIS provides up to 50 different descriptors for U.S. maps and charts, including map sets, series, single sheets, and mapping byproducts. Descriptors include survey data, features, geographic extent of coverage, map insets, irregular boundaries, and historic information. The Center also performs in-depth research for professional users.

NCIC regional offices are as follows:

For users in Illinois, Michigan, Minnesota, and Wisconsin:

Mid-Continent Mapping Center--NCIC
1400 Independent Rd.
Rolla, MO 65401
314/341-0851

For users in Indiana and Ohio:

Eastern Mapping Center--NCIC
536 National Center
Reston, VA 22092
703/860-6336

The USGS Geographic Names Information Section is developing alphabetical finding lists for each state. Included for each official name of listed geographical features are the feature class; location parameters such as Federal Information Processing Standards (FIPS) State/County codes and coordinates; elevation; and listings of pertinent topographic maps. These lists, completed for Illinois, Indiana, and Wisconsin, are available in the form of printouts, micofiche or magnetic tape and may be ordered from:

U.S. Ceographical Survey, NCIC
507 National Center
Reston, VA 22092
703/860-6045

Information and specialized searches may be requested from:

Roger Payne, Manager GNIS
U.S. Geographical Survey
523 National Center
Reston, VA 22092
703/860-6261

- <u>Office of Earth Sciences Applications</u>
  708 National Center
  Reston, VA 22092
  703/860-6981

This office will answer questions about the USGS's multidisciplinary environmental studies and the U.S. Department of the Interior's interagency environmental studies, which translate earth-science information into formats and language suitable for use by land and resource planners, decision-makers, and the general public. These studies include environmental impact reports, studies on geologic hazards, applications of remote sensing, and applications of earth-science data to land and resource planning and management. Requests for specific information will be directed to appropriate specialists.

- <u>Earth Resources Observation System (EROS)</u>
  EROS Data Center
  User Services Unit
  Sioux Falls, SD 57198
  605/594-6511

The EROS Data Center is the primary distribution center for NASA's Landsat multispectral earth imagery; aerial photographs acquired by the Department of Interior; and photographs and imagery acquired by NASA from research aircraft and satellites and from Skylab, Apollo and Gemini spacecraft. Its services are based on a comprehensive computerized system that catalogs all available remotely sensed data to facilitate on-line searching and automatic document ordering. The Applications Assistance Facility at the EROS Data Center provides inquiry and order capabilities. Scientists are also on hand to provide assistance in the application of the data to environmental problems and also in ordering data from the Center.

The Center promotes the use of remote sensing for solving land resource and environmental management problems by providing technical assistance in the interpretation and manipulation of the data; in conducting formal training in the technology of remote sensing and its applications; and in maintaining a library collection on remote sensing. The Center distributes aerial photographs, film negatives, catalogs, and other data that it acquires from the LANDSAT satellites, the Earth Resources Experiment Package included in NASA's Skylab program, NASA's survey aircraft program, and the USGS's aerial photography missions. The Center's publications include Color Composite Pictures (available monthly); Index of Cloud-Free LANDSAT Coverage of the U.S. (updated monthly); and a brochure describing the Center's services in detail. The Center's computerized services are based on the Imagery Data Base file, which allows searching of all photographic and electronic data on such specific characteristics as geographic area, individual flight, project name, geographic coordinates, image quality, cloud cover, sensor platforms, and others.

There is an EROS Data Reference File in the Columbus, Ohio USGS Water Resource Division Office (see Section II for address). Microfilm copies are kept of data available from the Center, and assistance is provided to visitors in reviewing and ordering data.

- <u>Geography Program</u>
  National Mapping Division
  710 National Center
  Reston, VA 22092
  703/860-6344

The Geography Program collects and analyzes land use data on a nationwide basis, develops methods of applying these data, and demonstrates the usefulness of the data to potential users. A primary activity of the program is mapping land use and land cover and preparing associated maps showing political units, hydrologic units, census county subdivisions, and federally-owned land for the entire United States. The Geography Program developed a two-level land use and land cover classification system, and a computer-based Geographic Information Retrieval and Analysis System (GIRAS) to facilitate computer manipulation, graphic output, presentation of statistical tabulations, and geographic analysis of land resourse use. Source data consists primarily of aerial photographs, with secondary input derived from remotely sensed data from satellites, maps, and data currently available from other federal agencies, together with field verification when necessary. Publications of the USGS Geography Program include: 1) Land Use Map series--land use and cover maps; 2) A Land Use and Land Cover Classification System for Use with Remote Sensor Data; 3) GIRAS: A Geographic Information Retrieval and Analysis System for Handling Land Use and Land Cover Data; and 4) Land Use and Land Cover Information and Air-Quality Planning. Copies may be ordered from:

USGS Branch of Distribution
1200 S. Eads St.
Arlington, VA 22202

The functions of GIRAS include: 1) digital storage of land use and land cover and associated maps; 2) cartographic editing and updating of the geographic data base; and 3) manipulation and retrieval of data for performing area measurements, map compositing analysis, and statistical and other computer-aided operations such as the matching of land use maps with other environmental, demographic, and economic data. Digital tapes of maps are on open file with the National Cartographic Information Center (NCIC). The Program also answers technical inquiries in its area of specialization.

2. State Geologists and Other State Sources

ILLINOIS
Jack A. Simon
Illinois State Geological Survey
121 Natural Resources Bldg.
Urbana, IL 61801

INDIANA
John B. Patton
Indiana Geological Survey

Dept. of Natural Resources
611 N. Walnut Grove
Bloomington, IN 47401
812/335-2863

(Sections: Geological Survey, Coal and Industrial Minerals, Geochemistry, Geology, Geophysics, Petroleum, Publications, and Educational Services)

MICHIGAN
Arthur E. Slaughter
Michigan Dept. of Natural Resources
Geological Survey Division
P. O. Box 30028
Lansing, MI 48909
517/373-1256

MINNESOTA
Matt S. Walton
Minnesota Geological Survey
University of Minnesota
1633 Eustis St.
St. Paul, MN 55108

OHIO
Horace R. Collins
Ohio Division of Geological Survey
Fountain Square, Bldg. 6
Columbus, OH 43224
614/469-5344

- Division of Land Pollution Control: 614/466-8934

- Division of Public Water Supply

  Ohio Environmental Protection Agency
  361 E. Broad Street
  Columbus, Ohio 43215
  614/466-8307

WISCONSIN
Meredith E. Ostrom
Wisconsin Geological & Natural History Survey
University of Wisconsin
1815 University Ave.
Madison, WI 53706
608/262-1705

3. Other Sources -- Further sources of topographic and geologic data include:

- Office of the Planning Coordinator (OPC)
  Ohio Environmental Protection Agency (OEPA)
  361 E. Broad Street
  Columbus, OH 43215
  614/466-7232

The Office of the Planning Coordinator in OEPA maintains a computerized geographic information system known as the Planning Engineering Data Management System for Ohio (PEMSO). Topographic and hydrologic data as well as modeling are available on this system.

- Soil Conservation Service maps and surveys (see following section)

- Data from well drillers' logs

- Geology departments of local colleges and universities.

4. <u>Hazardous Materials</u>

- Office of Pesticides and Toxic Substances
  US Environmental Protection Agency
  TS 777
  401 M Street S.W.
  Washington, D.C. 20460

  Walter Kovalick, Acting Director of the Chemical Coordination Staff: 202/382-3375

  Marsha Ramsay (state programs): 202/382-3405

Questions concerning information on toxics are handled through the Office of Pesticides and Toxic Substances (OPTS) whose purpose is to provide information on toxics-related activities being conducted as well as coordination of chemical data and activities. Documents prepared by the OPTS cover cross-agency information on chemical/regulatory activity for Federal as well as state (on a reduced level) programs.

EPA's Region V maintains the Remedial Response Information System (ERRIS), a site inventory computerized database of approximately 2,900 designated hazardous waste sites in the six states. Searches may be performed by location (state and county levels), by site name, or by EPA Site Identification Number. Requests should be sent to the following address:

Freedom of Information Office
USEPA, Region V
230 S. Dearborn
Chicago, IL 60604

B. SOILS

1. Soil Conservation Service (SCS)
U.S. Department of Agriculture
P. O. Box 2890
Washington, D.C. 20013
202/447-4543

The Soil Conservation Service is responsibile for developing and implementing a national soil and water conservation program through technical and consultative assistance to 2,950 local conservation districts; to sponsors of watershed protection and resource conservation and development projects; and to many other individuals and groups. The SCS appraises the status and condition of soil, water, and related resources, and trends in their use; designs long-range conservation programs with the aid of local soil conservation districts and the public; and evaluates progress in meeting conservation needs. SCS inventory and monitoring data are used at all governmental levels for conservation, use and development of land, and also for the protection of the environment.

The SCS publishes complete environmental baseline soils data in the form of county soil surveys. These surveys are conducted to determine soil use potentials and conservation treatment needs, and give detailed information on the kinds of soils in each county, where they are located and how they can be used. In addition to descriptions of the county's soil types and maps showing their distribution, the surveys identify the capabilities of the county's various soils for agriculture, wildlife habitat, and forestry; the location of prime and unique farmland; and the suitability of the county's soils for such uses as septic tanks, land treatment, construction of roads and buildings, and water supply and sewerage systems. Information is provided on properties such as soil texture, permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Additional information is provided on depth to water table, flooding hazards, depth to bedrock, and relief characteristics. Appendix A is a list of the published surveys for each county by state.

Soil surveys can be obtained through the District Conservationist in each county, who also maintains information on local geology, groundwater, surface water hydrology, erosion, sedimentation, and land use. District Conservationists' addresses in counties of the six states may be obtained from the following state offices of the Soil Conservation Service:

2. State Soil Conservationists and Offices

ILLINOIS
John J. Eckes
Springer Federal Bldg.
301 N. Randolph
Champaign, IL 61820
217/398-5265

INDIANA
Robert L. Eddleman
Corporate Square-West, Suite 2200
5610 Crawfordsville Rd.
Indianapolis, IN 46224
317/269-3785

MICHIGAN
Homer R. Hilner
1405 S. Harrison Rd.
E. Lansing, MI 48823
517/~~372-1910~~

MINNESOTA
Harry M. Major
200 Federal Bldg.
U.S. Courthouse
316 N. Robert St.
St. Paul, MN 55101
612/725-7675

OHIO
Robert R. Shaw
200 North High Street
RM 522
Columbus, OH 43215
614/469-6962

WISCONSIN
Cliffton A. Maguire
4601 Hammersley Rd.
P. O. Box 4248

Madison, WI 53711
608/252-5351

The Ohio Environmental Protection Agency (Ohio EPA) is another state source of Ohio soils information. Its PEMSO database supplies information on soil associations and engineering characteristics. User information is available from:

Office of the Planning Coordinator
Ohio EPA
361 E. Broad St.
Columbus, OH 43215 614/466-7232

C. ATMOSPHERE

1. Emissions and Air Quality

Data on stationary source emissions and ambient air quality may be obtained through:

U.S. EPA
National Air Data Branch (NADB)
Office of Air Quality Planning and Standards
Monitoring and Data Analysis Division
MD-14
Research Triangle Park, NC 27711
919/541-5491

The NADB is responsible for collecting, validating, analyzing, and disseminating data relating to the air quality of the nation. It maintains two computerized data systems: Storage and Retrieval of Aeromatric Data (SAROAD) and National Emissions Data System (NEDS). SAROAD holds aerometric data reported by monitoring stations located throughout the U.S., while NEDS contains data on pollutant emissions and their sources across the country. In addition to providing services directly from these data banks, the NADB also publishes data reports and compilations. Data are gathered by EPA, its contractors, and other government agencies at all levels. The NEDS data bank covers 140,000 point sources of emissions in 3,300 areas of 55 states and territories; SAROAD holds 95 million aerometric data items from over 9,000 air monitoring stations from 1958 to date. NADA publications include: 1) Air Quality Data Report (quarterly);

2) Emissions Data Report (semiannual); 3) Air Quality Data from the National Air Surveillance Networks and Contributing State and Local Networks (annual). All publications are available from:

Environmental Protection Agency
Air Pollution Technical Information Center
Research Triangle Park, NC 27711

Aerometric and emissions data from SAROAD and NEDS are distributed in machine-readable form to authorized persons. Data are also available through EPA's regional offices, which have direct access to the central EPA computer in Research Triangle Park.

The USEPA library in Research Triangle Park performs literature searches on a broad range of air quality data. They may be contacted directly at:

US Environmental Protection Agency Library
MD-35
Research Triangle Park
North Carolina, 27711
919/541-2777

or through the USEPA Region V Library at:

US Environmental Protection Agency
Region V Library
230 S. Dearborn
Rm. 1420
Chicago, IL 60604
Lou Tilley, Regional Librarian
312/353-2022

The USEPA Region V Library is also a valuable source of air quality data and should be contacted initially for literature searches.

2. Climatic Conditions

State and local area meteorological summaries, as well as special assistance with climatological problems, may be obtained from:

National Climatic Center (NCC)
National Oceanic & Atmospheric Administration

Federal Bldg.
Asheville, NC 28801
704/258-2850

The NCC, as the custodian of U.S. weather records, routinely collects, evaluates, publishes and distributes climatological data. The NCC furnishes data in the particular form and quantity needed, prepares special tabulations or summaries on request, and provides referrals to private meteorological consultants for those who require assistance in interpreting the information supplied. The scope of NCC data covers global (surface to 500,000 feet) meterological elements including clouds, temperature, humidity, pressure, visibility, wind direction, wind speed, precipitation, and solar radiation.

3. State Agencies

Each of the six states, with the exception of Minnesota, publish an Annual Air Quality Report which contains ambient air quality data for the previous year by Air Quality Control Region (AQCR). The Annual Air Quality Reports present ambient air quality data for the six regulated air pollutants (sulfur dioxide, particulates, carbon monoxide, ozone, nitrogen dioxide and lead) as well as information on a AQCR's attainment or nonattainment status. In some cases, air quality trends also are described. The Annual Air Quality Reports can be obtained from:

Ohio EPA
Division of Air Pollution Control
361 E. Brand St.
Columbus, OH 43215
Attn: Eric Klein
614/462-6269
($5 charge)

Indiana Board of Health
Bureau of Engineering
Air Pollution Control Division
1330 W. Michigan St.
Indianapolis, IN 46206
Attn: Debbie Parker
317/633-0621

Illinois EPA
Division of Air Pollution Control
2200 Churchill Road

Springfield, IL 62706
Attn: Ambient Air Monitoring Section
217/782-7326

Michigan DNR
Environmental Protection Bureau
Air Quality Division
P. O. Box 30028
Lansing, MI
517/322-1339

Wisconsin DNR
Bureau of Air Management
Monitoring Section
P. O. Box 7921
Madison, WI 53707
Attn: Julian Chazin
608/266-1902

Although Minnesota no longer publishes an Annual Air Quality Report, ambient air quality data can be obtained by writing to:

Minnesota Pollution Control Agency
Division of Air Quality
1935 W. County Rd., B-2
Roseville, MN 55113
Attn: Gary Eckhardt
612/296-7333

III. WATER RESOURCES

WATER RESOURCES DATA AVAILABLE FROM THE U.S. GEOLOGICAL SURVEY (USGS)

Three offices of the USGS collect and disseminate water resources data on a national basis: the Office of Water Data Coordination (OWDC), the National Water Data Exchange (NAWDEX), and the National Water Data System (NWDS), which maintains the computerized WATSTORE database.

. . Office of Water Data Coordination (OWDC)
427 National Center
Reston, VA 22092
703/860-6931

The OWDC was established to coordinate water data acquisition. It prepares and distributes a handbook on recommended methods for water data acquisition, and disseminates information about the water data acquisition activities of both federal and non-federal agencies through the publication of a series of indexes:

- Index to Catalog of Information on Water Data -- Lists information on surface water and groundwater stations. Published in 21 volumes corresponding to the water resource regions of the U.S.
- Index to Stations in Coastal Areas -- A special index covering stations on ocean and Great Lakes coasts in the U.S.
- Index to Water Data Activities in Coal Provinces of the U.S. (2 vols.)
- Federal Plan for Acquisition of Water Data (annual).

-. National Water Data System (NWDS)
440 National Center
Reston, VA 22092
703/860-6877

Working through a nationwide array of observation sites, the NWDS collects data on the occurrence, quality, quantity, distribution, and movement of the surface and underground waters constituting the water resources of the U.S. These data are stored in a large-scale computerized system (WATSTORE). The system consists of machine-readable files holding both water data and information on the collection sites, and it produces a variety of services ranging from simple data retrieval to complex statistical analyses. THe NWDS also distributes data through the annual publication of numerous hydrologic reports and maps. Its scope and subject matter include surface water stage and discharge, chemical quality parameters, radiochemistry, sediment, pesticide and biological concentrations, water levels, geological information relating to groundwater, and flood frequency and flood inundation mapping. WATSTORE's computer files hold over 300,000 station-years of records, plus location information for some 125,000 collection sites. NWDS also publishes the USGS series on water data for streamflow, water quality, and groundwater annually on a state boundary basis. WATSTORE is accessible through the USGS Water Resources Division, whose headquarters and district offices are listed below:

U.S. Geological Survey
Water Resources Division
441 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092
703/860-6801

ILLINOIS
Champaign County Bank Plaza
102 East Main, 4th Floor
Urbana, IL 61801
217/398-5353

INDIANA
6023 Guion Rd., Suite 201
Indianapolis, IN 46254
317/927-8540

MICHIGAN
6520 Merchantile Way, Suite 5
Lansing, MI 48910
517/377-1608

MINNESOTA
702 Post Office Bldg.
St. Paul, MN 55101
612/725-7841

OHIO
975 W. 3rd Ave.
Columbus, OH 43212
614/469-5553

WISCONSIN
1815 University Ave., Rm 200
Madison, WI 53706
608/262-2488

3. National Water Data Exchange (NAWDEX)
421 National Center
Reston, VA 22092
703/860-6031

NAWDEX is a confederation of government, academic, and private water-oriented organizations working together to help users identify, locate, and acquire needed information on the quantity and quality of surface and groundwaters. It services are based on a computerized directory of domestic and foreign organizations providing water data, and a computerized index to sites for which water data is available. Working in a nationwide network, 59 assistance centers provide access to these data bases and furnish local-area expertise in the identification and location of needed data. NAWDEX's machine-readable files hold information on over 350,000 water data collection sites and more than 650 water-oriented organization. NAWDEX publishes a periodic newsletter, a directory of assistance centers, and a variety of program-related documents. A bibliography is available on request. NAWDEX can also be accessed through USGS Water Resources Division state offices.

In addition to USGS's numeric hydrology and water quality data, published hydrologic maps are available showing circulation and distribution of surface and ground waters, aquifers and recharge areas, and some water quality information. Floodplain maps are available from the Flood Insurance Administration, the U.S. Army Corps of Engineers, and the Soil Conservation Service. Wild and Scenic Rivers maps showing rivers that are both designated and under study, are available from the National Park Service.

B. WATER RESOURCES DATA AVAILABLE FROM THE SOIL CONSERVATION SERVICE

In addition to providing assistance with soils data as outlined above, the Soil Conservation Service has access to large amounts of water resources information that has been collected in connection with the numerous projects that the SCS has conducted in its many areas of responsibility.

The major SCS programs constituting this fund of information are as follows:

- River Basin Surveys and Investigations -- The SCS, along with other agencies within the Department of Agriculture (the Economic Research Service, the Forest Service, and the Science & Education Administration), cooperates with other Federal, state, and local agencies in studying the watersheds of rivers and other waterways. These studies include cooperative river basin surveys that serve as a basis for developing coordinated water resource programs; floodplain management studies that furnish technical data, assistance, and information for state and local governments to use in floodplain management programs; joint watershed surveys with the U.S. Army Corps of Engineers for the purpose of flood prevention; and coordination of interagency water resources activities.

- Watershed Planning Studies -- The SCS has general responsibility for the administration of investigations and surveys of proposed small watershed projects in response to requests by sponsoring local organizations. The SCS assists sponsors in the development of watershed plans.

- Data from Watershed and Flood Prevention Operations — The SCS administers cooperative activities with local sponsors, state agencies, and other public bodies in the planning and implementation of projects for erosion, floodwater, and sediment damage control; conservation and development of water resources; water utilization and disposal; flood prevention projects, including development of recreational facilities and improvement of fish and wildlife habitat; and also provides loans to local organizations through the Farmers Home Administration to help finance the local share of the cost of such projects. The SCS is also responsibile for carrying out emergency watershed protection measures.

- Resource Conservation and Development Studies — The SCS has general responsibility for assisting local units of government in the planning and development of land and water resources in multiple-county areas. Projects in this area include erosion control, flood prevention, farm irrigation, water-based recreation, fish and wildlife facilities, agricultural pollution control, and water quality protection.

- <u>Rural Abandoned Mine Program</u> -- In this program, the SCS assists land users in the reclamation of abandoned or inadequately reclaimed coal-mined lands and associated water bodies. The SCS also is responsible for helping to identify areas of prime farmland that may be surface-mined in the future, providing technical assistance to mine operators for reclaiming coal-mined lands, reviewing permits for surface mining which involve prime farmland, and reviewing state reclamation plans.

Additional SCS programs include:

- Agricultural Conservation Program
- Rural Clean Water Program
- Waterbank Program
- Great Plains Conservation Program.

Data from all of the above studies and programs of the SCS are available through county-level SCS District Conservationists.

C. OTHER SOURCES

1. U.S. Environmental Protection Agency

a. STORET

Office of Water and Hazardous Materials
Monitoring and Data Support Division
Information Access and User Assistance Branch
WH-553
401 M Street, S.W.
Washington, D.C. 20460
202/382-7220

STORET is a large-scale computerized STOrage and RETrieval system for water pollution measurement data collected from observation stations across the country. Available for on-line retrieval from remote terminals, the system is designed to serve planning and management personnel, and provides a systematic state, regional, and national data base for reporting trends in water quality. Its water pollution data are derived from laboratory analyses of water samples. The data are acquired from the USGS's National Water Data System and from a variety of pollution abatement agencies at

Federal, state, and local levels. STORET's machine-readable files hold about 60 million historical monitoring observations from over 500,000 locations. STORET data are available for on-line retrieval at EPA's Region V office in Chicago:

Stuart Ross, Regional STORET Representative
Data Management Section, 5MSD11
US Environmental Protection Agency
Region V
230 S. Dearborn
Chicago, IL 60604
312/353-0299

On-line data may also be obtained from offices located in most state capitals, or from users' own terminals. STORET data are also provided in magnetic tape or printout form.

b. National Eutrophication Study Data Base
Environmental Monitoring Systems Laboratory
P. O. Box 15027
Las Vegas, NV 89104
702/736-2969

The National Eutrophication Study Data Base holds water quality data collected over a one-year period for each of some 800 lakes and their tributaries in 48 states. Maintained as part of EPA's STORET system, the data base contains physical, chemical, and biological water quality data. The study characterised the degree of eutrophication for each of the lakes studied as well as the sources of nutrients to the lakes. Other publications include state summaries of algal data, reports on methods, and comprehensive data analyses.

c. Large Lakes Research Laboratory (LLRL)
Office of Research and Development
9311 Groh Rd.
Grosse Isle, MI 48138
313/675-5000

As an adjunct to its research on Great Lakes water quality, the LLRL acquires, stores, analyzes, and disseminates water data, which is compiled in machine-readable form as the Great Lakes Water Quality Data Base. The data covers related tributaries and watersheds as well as the Lakes themselves. Data are acquired through surveys, regular monitoring and surveillance, and specifically designed research efforts.

2. U.S. Army Corps of Engineers (COE)

Data on floods, flood-prone areas, flood frequencies, flood control structures, and floodplain management are available in the form of numeric files, maps, and published reports from national headquarters and District COE offices. The Division and District boundaries for the COE offices listed below are depicted in Figure 1.

Office, Chief of Engineers
Department of the Army
Washington, D.C. 20314
202/693-6456

North Central Division
536 Clark St.
Chicago, IL 60605
312/353-6385

Chicago District
219 S. Dearborn St.
Chicago, IL 60604
312/353-6412

Detroit District
P. O. Box 1027
Detroit, MI 48231
313/226-6413

Rock Island District
Clock Tower Bldg.
Rock Island, IL 61201
309/788-6361

St. Paul District
1135 USPO & Customhouse
St. Paul, MN 55101
612/725-7506

Ohio River District
P. O. Box 1159
Cincinnati, Oh 45201
513/684-3001

Figure 1. COE Division/District boundaries

3. National Flood Insurance Program

The National Flood Insurance Program (NFIP) provides Federally-subsidized flood insurance to individuals and businesses located in flood-prone areas. For property owners to qualify for Federally-subsidized flood insurance, the local government having jurisdiction over the property must adopt and enforce land use controls that lessen or avoid damage in flood-prone areas. Flood Insurance Rate Maps are available from the NFIP which depict 500- and 100-year flood boundaries, contours showing the base flood (100-year) elevation, and flood zone designations. Major flood protection structures also are depicted on the Rate Maps. The Maps can be obtained from:

National Flood Insurance Program
P. O. Box 34222
Bethesda, Maryland 20817
800/638-6620 or
800/424-8872

4. NOAA Regional Coast Information Center (RCIC) Network
11400 Rockville Pike
Rockville, MD 20852
301/443-8137

The RCIC network is jointly sponsored by the following NOAA offices: Environmental Data and Information Service (EDIS), Office of Coastal Zone Management, Office of Sea Grant, and National Marine Fisheries Service. The network consists of regional clearinghouses which disseminate information needed for the management of the coastline and its resources. Subject areas in which the RCIC Clearinghouse provides assistance include aquaculture; beaches and dunes; biological, chemical, and physical oceanography; coastal history; coastal zone management; dredging and disposal; erosion and accretion; fisheries, forestry, and wildlife; geology and natural hazards; marine law, regulations, and permits; water resources; marshes, estuaries, and wetlands; pollution control and water quality; ports, harbors, and marinas; recreation; remote sensing; aerial photography; and maps. Services are provided in the form of information retrieval and referral. Input sources to the RCIC include organizations and individuals performing research, marine library collections, and commercial and governmental data bases.

5. Water Resources Scientific Information Center (WRSIC)
Office of Water Research & Technology (OWRT)
U.S. Department of the Interior
18th & C Sts., N.W., Rm. 1308
Washington, D.C. 20240
202/343-8435

The WRSIC disseminates scientific and technical information to the water resources management and research community through print and computer-based services. It prepares the Selected Water Resources Abstracts (SWRA) journal and maintains an equivalent computer-readable database. It also produces a water resources research project database on current research in progress. WRSIC services in EPA Region V states are provided by:

University of Wisconsin
Water Resources Center
215 N. Randall Ave.
Madison, WI 53706
608/262-3577

6. U.S. Department of Agriculture Water Data Library
Science & Education Administration (SEA)
Rm. 236, Bldg. 007, BARC
Beltsville, MD 20705
301/344-3550

The Water Data Laborarory maintains and utilizes a computerized storage and retrieval system for hydrologic data obtained at the several SEA Watershed Hydrology Research Centers. It disseminates these data through published annual summaries and microfilm products. Their annual publication is entitled Hydrologic Data For Experimental Agricultural Watersheds in the U.S. Included in these products are annual, monthly, and daily precipitation and streamflow data; temperature; evaporation; wind movement; soil moisture; and land use and land cover conditions. The Water Data Laboratory maintains data files from about 160 active and 55 inactive watershed studies covering the period from 1930 to the present.

7. Wisconsin Water Resources Information Program (WRIP)
University of Wisconsin-Madison
Water Resources Center and Engineering
and Physical Sciences Library
215 N. Randall Ave.
Madison, WI 53706
608/262-0561

The WRIP is responsible for selecting, indexing, and abstracting documents for input to Selected Water Resources Abstracts. In addition to directly searching SWRA and other data bases on a cost-recovery basis, the WRIP also provides research, referral, and manual literature search services.

8. <u>State and Regional Sources</u>

<u>ILLINOIS</u>

Illinois Department of Transportation
Division of Water Resources
2300 S. Dirksen Parkway
Springfield, IL 62764

- Bureau of Planning: Prepares flood control studies for communities; reports available through the Bureau and State Library: 217/782-4636

Illinois State Water Survey
605 E. Springfield
P. O. Box 5050, Station A
Champaign, IL 61820

- Researches and prepares reports on both surface and groundwater quality as well as atmospheric quality as it pertains to water resources: 217/333-4952

Illinois Water Resources Center
University of Illinois
2535 Hydrosystems Laboratory
208 N. Romine St.
Urbana, IL 61801

- Coordinates water resources research program in Illinois supported by university and Federal funds and publishes reports for the various projects including water quality, management, treatment, and on aquatic biota: 217/333-0536

<u>INDIANA</u>

Indiana Department of Natural Resources
Division of Water
State Office Bldg., Rm. 605
100 N. Senate Ave.
Indianapolis, IN 46204

- Duties include permitting, planning for flood insurance purposes, as well as compilation of hydraulic data on surface and groundwaters; data and reports are available at the cost of reproduction: 317/232-4160

Division of Water Pollution Control
Indiana State Board of Health

1330 West Michigan Street
Indianapolis, IN 46206

- Provides technical and administrative services in water pollution control. Data is available for surface (quality, quantity, and use) and ground (quality and use) waters: 317/633-0700

OHIO

Ohio River Basin Commission
36 E. 4th St.
Cincinnati, OH 45202
513/684-3831

- Office of the Planning Coordinator (drainage network through PEMSO, nonpoint source pollution, floodprone area maps)

- Division of Public Water Supply (groundwater hydrology, quality and use): 614/466-8307

- Division of Wastewater Pollution Control, Surveillance and Standards Section (major river basin water quality data): 614/466-7427

Ohio Environmental Protection Agency
361 E. Broad Street
Columbus, OH 43215

- Water Inventory Section (groundwater data, precipitation data, Monthly Water Inventory Report): 614/265-6739

- Floodplain Management Unit (floodplain data, published reports, and maps): 614/265-6755

- Water Planning Unit (regional water plans, water resources data for various uses): 614/265-6756

The above offices of the Ohio DNR, Division of Water may be contacted at:

Ohio DNR
Division of Water
Fountain Square
Columbus, OH 43224
614/265-6717

Ohio River Valley Water Sanitation Commission
414 Walnut St.
Cincinnati, OH 45202
513/421-1151

Ohio Water Resources Center
Ohio State University
1791 Neil Ave.
Columbus, OH 43210
614/422-2334

MINNESOTA

Upper Mississippi River Basin Commission
Rm. 210
7920 Cedar Avenue, South
Minneapolis, MN 55420
612/725-4690

Minnesota Water Resources Research Center
866 Biological Sciences Center
University of Minnesota
St. Paul, MN 55108
612/376-5668

WISCONSIN

Wisconsin Department of Natural Resources
Division of Environmental Standards
P. O. Box 7921
Madison, WI 53707

- Bureau of Water Resources Management, Bruce Baker, Director (information available on surface and ground water quality standards, modeling, surveys and planning): 608/266-8631

- Bureau of Wastewater Management, Carl Blabaum, Director (information available on industrial and municipal discharge permits, monthly operating information, and construction plan reviews): 608/266-3910

- Bureau of Water Supply, Robert Krill, Director (information available on public and private water supply systems including operating and construction records): 608/267-7651

State and local water and public health agencies can be consulted for the following types of data:

- Epidemiological studies

- Previous waste treatment facility plans

- Wastewater management studies

- Hydrologic records

- Existing water use records

- Raw and treated water quality data
- Water treatment and distribution systems information
- Studies completed under the Clean Water Act, including 201 facilities plans, 208 areawide plans, and 303 basin plans
- Historical water quality data and survey records.

Washington, D.C. 20240
202/343-5994

Land use data may also be obtained from the Bureau of the Census (Agricultural Census data), the U.S. Forest Service and the Soil Conservation Service (forest and agricultural acreages), the Fish & Wildlife Service and the Forest Service (recreational areas), and the Bureau of Economic Analysis (projections of industrial development).

Much valuable information may also be obtained on present and future uses of land from regional planning commissions and state planning departments. This information includes industrial and commercial development, uses of under-developed and vacant land, sensitive and hazardous areas, farmland preservation, recreational open space, floodplain and wetlands management, and other activities that may affect the degree and location of future growth. This information may be obtained from regional land use plans, transportation plans, water and sewer plans, capital improvement plans, 208 plans (drainage basin studies), and recreation and open space plans. In addition, regional and state planning agencies can often furnish current population and housing information, as well as data in almost every other category covered herein.

2. <u>Regional Planning Councils</u>

ILLINOIS

Southern Five Regional Planning District
and Development Commission
202 South St.
Anna, IL 62906
618/833-2106

Barrington Council of Governments
132 W. Station
Barrington, IL 60010
312/381-7871

Belvidere-Boon County Regional Planning Commission
613 North Main St.
Belvidere, IL 61008
815/544-5271

McLean County Regional Planining Commission (M)
Illinois House, Suite 201

B. U.S. FISH & WILDLIFE REFERENCE SERVICE (FWRS)
Denver Public Library
3840 York St.
Denver, CO 80205
303/571-4656

The FWRS is a computerized information retrieval system designed to provide state-level research information on American fish and wildlife to biologists and management personnel. It indexes selected state fish and game agency technical reports to compile a computer-readable data base from which is offered bibliographies and research indexes by state. Copies of the original literature are also available in paper or on microfiche. FWRS's free quarterly newsletter gives a listing of new reports available.

C. U.S. ARMY CORPS OF ENGINEERS (COE)

The COE collects a great deal of biological information in the course of its research and development, environmental engineering, and water resource management activities.

A particularly valuable source of information on endangered species is a computerized system called the Sensitive Wildlife Information System (SWIS). The COE operates SWIS in cooperation with the U.S. Fish & Wildlife Service, the U.S. Forest Service, the Federal Highway Administration, and the Soil Conservation Service. SWIS provides information arranged by state on the habits and habitat requirements of selected endangered or protected species and other environmentally sensitive wildlife. Its primary purpose is to aid the engineer and land manager in the planning and development of resource projects and environmental impact statements. Included for each taxon is information on the degree of protection accorded under Federal and state law; its geographic distribution; its known behavioral characteristics and habitat requirements, especially in regard to its adaptability to changes in its environment; its population structure and trends; and a reference bibliography. In addition to providing this information in narrative form, SWIS also produces computer-plotted distribution maps for each animal covered.

The information in SWIS is gathered from federal, state, university, and other biologists, botanists, and ecologists; federal, state, university and commercial publications and data bases; and several major libraries. SWIS is available without cost to users who are authorized by the sponsoring agencies. Its address is:

Sensitive Wildlife Information System (SWIS)
U.S. Army Corps of Engineers
Waterways Experiement Station
P.O. Box 631
Vicksburg, MS 39180
601/634-2108

D. U.S. FOREST SERVICE

Information of vegetative cover, wildlife habitats, and forestry uses and management may be obtained from the U.S. Forest Service, whose national and regional offices are as follows:

- Area Planning and Development: 202/477-7403 (national)
- Forest Environmental Research: 703/235-1071 (regional)

U.S. Forest Service
Dept. of Agriculture
P.O. Box 2417
Washington, D.C. 20013
202/477-3957

Region 9 - Eastern Region
633 W. Wisconsin Ave.
Milwaukee, WI 53203
414/291-3693

North Central Research Station
1992 Folwell Ave.
St. Paul, MN 55108
612/642-5207

E. STATE SOURCES

Statistics, surveys, research reports, and other types of data on aquatic and terrestrial biology, wetlands, forests, and endangered species are available in many different forms from the state agencies and organizations listed below. In addition, local colleges and universities are often good sources of such data.

ILLINOIS

- Mammalogy Program, Ms. Carol Mahan
- Aviation Program, Mr. Vernon Kleen
- Natural Areas Program, Mr. John Schwegman
- Botany Program, Mr. John Schwegman

The mailing address for the above are:

Division of Forest Resources and Natural Heritage
Department of Conservation
600 N. Grand Ave., W.
Springfield, IL 62706
217/782-2361

Aquatic Biology:

- *stream and basin survey information*

Northern Illinois

Mr. Bill Bertrand
Northern Streams Program
P.O. Box 147
Aledo, IL 61231

Southern Illinois

Mr. Bill Boyd
Southern Streams Program
R.R. 2, Box 62A
Nashville, IL 62262

- Mussel Surveys
Mr. Bill Fritz
Commercial Fishing Program Manager
140 Lake Vista Drive
Carlyle, IL 62231

- Fish contaminant surveys, Les Frankland
- Annual Lake and Ponel surveys, Pete Palachino
- Fish Kill Surveys, Jim Mick
Illinois Department of Conservation
Division of Fish and Wild Life Resources
600 N. Grand Avenue. W.
Springfield, IL 62706

Terrestrial Biology

The following persons can be contacted concerning terrestrial biology requests:

- Upland Game Annual Census

  Mr. James Moak
  Upland Wildlife Program
  Baldwin Beach
  Havana, IL 62644

- Waterfowl Annual Census

  Mr. Dennis Thornburg
  Union County Refuge
  R.R. 2
  Jonesboro, IL 62952

- Furbearing Mammal Annual Surveys
  Road Kill Reports

  Mr. George Hubert
  P.O. Box 728
  168 Coster Street
  Hinckley, IL 60520

- Hunter Harvest Surveys

  Mr. Jack Ellis
  Wildlife Resource Analyst
  129 North Kennedy Blvd.
  Vandalia, IL 62471

- Deer and Turkey Harvest Surveys
  Turkey and Grouse Spring Surveys
  Squirrel Surveys, Mast Surveys

  Mr. Frosty Loomis
  Program Manager
  125 North 1st Street
  Monmouth, IL 61462

- Forest Resources

  Mr. Dick Little
  Section Manager
  Forest Resources and Management
  Divison of Forest Resources and Natural Heritage
  600 North Grand Avenue West
  Springfield, IL 62706

- Threatened and Endangered Species

Mr. Mike Sweet
Endangered Species Coordinator
Division of Forest Resources and Natural Heritage
600 North Grand Avenue West
Springfield, IL 62706

- Wetlands

Mr. Richard W. Lutz
Supervisor, Impact Analysis Section
Division of Planning and Information
Lincoln Tower Plaza
524 South Second Street
Springfield, IL 62706

- The Illinois Fish and Wildlife Information System (IFWIS)
Dr. Michael D. Morin
Division of Planning and Information
Lincoln Tower Plaza
524 S. Second Street
Springfield, IL 62706
217/782-4543

The IFWIS, a computerized database for existing species, is being developed by the Department of Conservation's Bureau of Program Services and Bureau of Natural Resources as well as the Illinois Natural History Survey. Information on 300 of the 1,000 total species on file should be available by July 1983.

- Illinois Streams Information System (ISIS)
Department of Conservation
Lincoln Tower Plaza
524 S. Second Street
Springfield, IL 62706
Mr. Gregg Tichncek, Project Coordinator
217/782-3884

- University of Illinois
Department of Landscape Architecture
214 Mumford Hall
1301 W. Gregory Drive
Urbana, IL 61301
217/333-0178

The ISIS database is a joint project of the University of Illinois and the Illinois Department of Conservation. Once completed, it will provide stream resource data for the approximately 2000 streams in Illinois whose watersheds are 10 square miles or larger. The database will include information on locational, chemical, physical, biological, cultural, recreational and development variables. The project is ongoing with future plans to include other water and geographical data.

Department of Energy and Natural Resources
Energy and Environmental Affairs
325 W. Adams
Springfield, IL 62706
Bill Frerichs
Manager of Environmental Research Section
217/785-8578

Information on publications available from the Energy and Environmental Affairs Section may be obtained by calling 800/252-8955.

- Botany and Plant Pathology Section, 217/333-6886
- Aquatic Biology Section, 217/333-4889
- Faunistic Surveys and Insect Identification, 217/333-6846
- Wildlife Research Section, 217/333-687[illegible]
- Fisheries Research Center, RD#1, Box 126, Kinmundy, IL 62854, 618/245-6348

These sections may be contacted at the following address:

Illinois State Natural History Survey Division
179 Natural Resources Bldg.
Urbana, IL 61801
217/333-6830

INDIANA

Division of Fish and Wildlife
Department of Natural Resources
607 State Office Bldg.
100 N. Senate Ave.
Indianapolis, IN 46204
317/232-4080

Extension Wildlife Specialist
Department of Forestry and Natural Resources
Purdue University
West Lafayette, IN 47907
317/494-8395

MICHIGAN

Fisheries Division
Department of Natural Resources
Stevens T. Mason Bldg., 6th Fl.
P. O. Box 30028
Lansing, MI 48909
517/373-1280

Wildlife Division
Department of Natural Resources
Stevens T. Mason Bldg., 6th Fl.
P. O. Box 30028
Lansing, MI 48909
517/373-1263

Fisheries and Wildlife Extension Specialist
Natural Resources Bldg.
Michigan State University
E. Lansing, MI 48824
517/337-6652

MINNESOTA

- Division of Fish, 612/296-3325

- Divison of Wildlife 612/296-3344

Department of Natural Resources
Centennial Office Bldg., Box 33
658 Cedar St.
St. Paul, MN 55155

Wildlife Extension Specialist
Agricultural Extension Service
University of Minnesota
240 Coffey Hall
St. Paul, MN 55108
612/373-1016

OHIO

Wildlife Conservation Extension Specialist
State Extension Services
Ohio State University
2001 Fyffe Ct.
Columbia, OH 43210
614/422-1981

Ohio Biological Survey
980 Biological Sciences Bldg.
Ohio State University
484 W. 12th Ave.
Columbia, OH 43210
614-422-9645

- G. Robert Stroh, Executive Administrator, 614/265-6314

- Division of Wildlife, 614/265-6300

- Fish Management Section, 614/265-6300

- Division of Forestry, 614/265-6694

- Division of Natural Areas and Preserves, 614/265-6453

The mailing address for the above Divisions of the Ohio DNR is:

Ohio Department of Natural Resources
Fountain Sq.
Columbus, OH 43224
614/265-6565

- Division of Water Pollution Control
  Surveillance and Standards Section
  614/466-7427
  (Fish, macroinvertebrate, FINS database for fish population data)

- Office of the Planning Coordinator (OPC)
  614/466-7232
  (PEMSO database for threatened or endangered species)

The mailing address for the above offices of the Ohio EPA is:

Ohio EPA
361 E. Broad Street
Columbus, OH 43215
614/466-8565

- Ohio Cooperative Fishery Research Unit
  614/422-8961

- Ohio Cooperative Wildlife Research Unit
  614/422-6112

The mailing address for the above is:

Ohio State University
1835 Neil Avenue
Columbus, OH 43210

Site specific data may be obtained through the Wildlife District Manager for each group of counties below:

Wildlife District One
1500 Dublin Rd.
Columbus, OH 43210
614/265-7038
(centrally located counties)

Wildlife District Two
952 Lima Ave.
Findlay, OH 45840
419/422-6757
(Northwestern counties)

Wildlife District Three
912 Portage Lake Drive
Akron, OH 44319
216/644-2293
(Northeastern counties)

Wildlife District Four
3600 E. State St.
Athens, OH 45701
614/594-2211
(Southeastern counties)

Wildlife District Five
1076 Old Springfield Pike
Xenia, OH 45385
513/372-7668
(Southwestern counties)

In Sundusky: 419/625-8062
In Cleveland: 216/621-7968

WISCONSIN

Department of Natural Resources
P.O. Box 7921
Madison, WI 53707

- Bureau of Fish Management, 608/266-7025
- Bureau of Wildlife Management, 608/266-2193
- Office of Endangered and Nongame Species, 608/266-9168

Geological and Natural History Survey
University of Wisconsin-Extension
1815 University Ave.
Madison, WI 53706
608/262-1705

Extension Wildlife Specialists
Cooperative Extension Program
University of Wisconsin
432 N. Lake St.
Madison, WI 53706
608/263-2071, 6325

Wisconsin Cooperative Fishery Research Unit
College of Natural Resources
University of Wisconsin in Stevens Point
Stevens Point, WI 54481
715/346-0123

Wisconsin Cooperative Wildlife Research Unit
Dept. of Wildlife Ecology
226 Russell Laboratories
Universities of Wisconsin-Madison
Madison, WI 53706
608/262-2671

V. SOCIOECONOMICS

A. POPULATION, HOUSING, AND COMMUNITY FISCAL CHARACTERISTICS

1. Bureau of the Census (BOC)
U.S. Department of Commerce
Data User Services Division
Washington, D.C. 20233
301/899-7600

The Bureau of the Census collects, tabulates, and publishes a wide variety of statistical data concerning the population and the economy of the nation. Its principal functions include decennial censuses of agriculture, state, and local governments, manufacturers, mineral industries, distributive trades, construction industries and transportation; current surveys which provide information on many of the subjects covered in the censuses at monthly, quarterly, annual, or other intervals; and compilations of current statistics on U.S. foreign trade. The Bureau also conducts special censuses for states and local government units; publishes estimates and projections of the population; provides current data on population and housing characteristics; and issues current reports on manufacturing, retail and wholesale trade, services, construction, imports and exports, state and local government finances and employment, and other subjects. The principal products of the Bureau are its printed reports, computer tapes, and special tabulations. It also produces statistical compendia, catalogs, guides, and directories that are useful in locating specific information. The following is a list of Bureau of the Census field offices in the six states, together with their areas of service:

Chicago Regional Office
55 E. Jackson Bldv.
Chicago, IL 60604
312/353-0980

- Illinois (all counties except Madison and St. Clair)
- Indiana (all counties except Clark, Dearborn, De Kalb, Floyd, and Steuben)

Detroit Regional Office
231 W. Lafayette
Detroit, MI 48226

V. SOCIOECONOMICS

A. POPULATION, HOUSING, AND COMMUNITY FISCAL CHARACTERISTICS

1. Bureau of the Census (BOC)
U.S. Department of Commerce
Data User Services Division
Washington, D.C. 20233
301/899-7600

The Bureau of the Census collects, tabulates, and publishes a wide variety of statistical data concerning the population and the economy of the nation. Its principal functions include decennial censuses of agriculture, state, and local governments, manufacturers, mineral industries, distributive trades, construction industries and transportation; current surveys which provide information on many of the subjects covered in the censuses at monthly, quarterly, annual, or other intervals; and compilations of current statistics on U.S. foreign trade. The Bureau also conducts special censuses for states and local government units; publishes estimates and projections of the population; provides current data on population and housing characteristics; and issues current reports on manufacturing, retail and wholesale trade, services, construction, imports and exports, state and local government finances and employment, and other subjects. The principal products of the Bureau are its printed reports, computer tapes, and special tabulations. It also produces statistical compendia, catalogs, guides, and directories that are useful in locating specific information. The following is a list of Bureau of the Census field offices in the six states, together with their areas of service:

Chicago Regional Office
55 E. Jackson Bldv.
Chicago, IL 60604
312/353-0980

- Illinois (all counties except Madison and St. Clair)
- Indiana (all counties except Clark, Dearborn, De Kalb, Floyd, and Steuben)

Detroit Regional Office
231 W. Lafayette
Detroit, MI 48226

Major Bureau of the Census Products

The major printed reports issued on the basis of the 1980 Census of Population and Housing include:

- PHV80-V, Final Population and Housing Counts
- PC80-1-A, Number of Inhabitants
- PHC80-V, Data for counties, county subdivisions, and incorporated places (counts of housing units and persons)
- PC80-1-B, General Population Characteristics (1,000 inhabitants or more)
- HC80-1-A, General Housing Characteristics
- PC80-1-C, General Social & Economic Characteristics
- HC80-1-B, Detailed Housing Characteristics
- PHC80-3, Summary Characteristics for Governmental Units and SMSAs

Intercensal population estimates and projections:

- P-25 and P-26 series Current Population Reports Published for each state, its counties and county equivalents, incorporated places, and active minor civil divisions (MCDs) in 20 states (Reg. V states included in the 20 are Illinois, Indiana, Minnesota, and Ohio).
- P-28 series Special surveys for counties and incorporated places.

Population and housing data from the 1980 census are also available in low-cost paper copy form or microfiche from NTIS. The reports are available for three commonly used geographic areas: state by county, state by named places with a population of 2,500 or greater, and nation by state and Standard Metropolitan Statistical Area (SMSA). Buyers receive a one-page comprehensive profile of information for each geographic area. For example, the State by County report includes information for the total state and for each individual county. For many states, this information is available for as little as $7.50. The largest report, which contains more than 600 profiles, is only $13.50.

Other Useful Bureau of the Census Products

- State and Metropolitan Area Data Book, 1982

This 700-page statistical compendium offers a detailed profile of the U.S. as a whole, as well as of regions, divisions, states, SMSAs, and the component counties and central cities of metropolitan areas. It contains data not only from the Census Bureau but also from many other government and private data sources. The topics covered include land area, population, housing, income, labor force, local government financing and employment, manufacturing, wholesale and retail trade, vital statistics, school enrollment, and many others. The publication is available for $15 from the Government Printing Office (Stock No. 003-024-04932-5).

For smaller communities, the BOC has issued a 12-page brochure focusing on census data available on counties, cities of less than 50,000 inhabitants, and county subdivisions such as townships. The brochure is entitled Data for Small Communities (CFF No. 22) and is available from the BOC Data User Services Division (BOC/DUSO).

Also available from BOC/DUSD is a recently issued 12-page brochure entitled A Preview of the 1982 Economic Censuses. It gives publication schedules and coverage for the censuses of manufacturers, mineral industries, construction industries, retail trade, wholesale trade, service industries, and special census programs.

The Data User Services Division of the Census Bureau publishes a monthly newsletter listing new BOC products. A subscription to this publication, entitled Monthly Product Announcement, is available free of charge from the DUSD. In addition, each State Data Center periodically publishes a newsletter highlighting recent data and products from the Bureau and other organizations.

Maps of SMSAs from the BOC's Number of Inhabitants (PC-80-1-A) 1980 Census report are available separately from BOC Customer Services. Also available are photocopies of county subdivision maps from the same report series, showing minor civil divisions and census county divisions.

- The DUSD also operates a National Clearinghouse for Census Data Services, and will, on request, provide a list of private and public organizations that offer tape printouts and other census data services to customers.

- Special tabulations: Data users with specific requirements not met by published data may order special tabulations on computer tapes or printouts by writing to the Director, BOC, Washington, D.C. 20233.

Additional publications available from the BOC include:

- Directory of Federal Statistics for Local Areas: A Guide to Sources ($5.50, available from GPO)

- Directory of Federal Statistics for Local Areas: Urban Update ($4.50, available from GPO)

- Government and Census Depository Libraries Holding Census Bureau Report (Available free from DUSD)

- Census 80: Introduction to Products and Services (Available free from DUSD)

- 1980 Census of Population and Housing: Users' Guide (")

- Reference Manual on Population and Housing Statistics from the Census Bureau (Available for $2 from DUSD)

- Economic Statistics Data Finders for agriculture, business, economic surveys, and industries (single copies free from DUSD)

2. Bureau of Economic Analysis (BEA)
U.S. Department of Commerce
Washington, D.C. 20230
202/523-0777

The BEA provides projections of future population in SMSAs which incorporate the "Series E" projections of the Bureau of the Census. These can be used to estimate current population and project future population for facility planning areas. Along with population projections to the year 2000, the BEA has provided totals for each state which show personal income, per capita income, and average earnings by occupation. The data and analyses prepared by BEA are disseminated primarily through its monthly publications, the Survey of Current Business, including periodic supplements to the Survey, and the Business Conditions Digest.

3. U.S. Department of Housing & Urban Development
HUD USER
Office of Policy Development and Research
P. O. Box 280
Germantown, MD 20767

HUD USER is a computer-based information service created by the Department of Housing and Urban Development to disseminate the results of HUD-sponsored research to the public. It provides automated literature searches from its database covering research reports; serves as a distribution center for Office of Policy Development and Research reports and announcements of new research; and produces and distributes abstract bibliographies and catalogs. It covers housing management, neighborhood conservation, community development, building technology, economic development, energy conservation, and any topic related to housing and urban development. HUD USER conducts free on-line searches and provides abstract citations of holdings, which are available in full text from NTIS. Manual literature searches and referrals are also offered.

4. State Sources of Population and Housing Data

ILLINOIS

Office of Housing and Community Development
Department of Commerce and Community Affairs
222 S. College St.
Springfield, IL 62706
217/782-3555

INDIANA

State Housing Board
Community Services Administration
111 N. Capitol St.
Indianapolis, IN 46204
317/232-7055

MICHIGAN

State Housing Development Authority
Department of Social Services
P. O. Box 30044
Lansing, MI 48909
517/373-8370

MINNESOTA

Minnesota Housing Finance Agency
333 Sibley St.
St. Paul, MN 55101
612/296-7608

OHIO

Office of the Planning Coordinator
Ohio EPA
361 E. Broad St.
Columbus, OH 43215
614/466-7232
(Demographic information in PEMSO database)

Ohio Housing Development Board
1200 Atlas Bldg.
8 E. Long St.
Columbus, OH 43215
614/466-7970

Ohio State Department of Economic and Community Development
Office of Research
30 E. Broad St.
Columbus, OH 43215
614/466-2115

Division of Wastewater Pollution Control
Special Projects Section
Ohio EPA
361 E. Broad St.
Columbus, OH 43215
614/460-7427
(Community fiscal data)

The Office of Research analyzes and disseminates economic and demographic information for all counties and municipalities in Ohio. It uses machine-readable U.S. Bureau of the Census data and other sources for annual population estimates, population projections, and county profiles. The Office issues an annual publication, Ohio Population Estimates.

Ohio Department of Development
Ohio Data Users Center
P. O. Box 1001
Columbus, OH 43216
614/466-2115

The Ohio Data Users Center (ODUC) supplies information on the economic and demographic characteristics of counties and the state. ODUC data notes, a free bi-monthly publication, details new developments in data and services available from ODUC and the US Bureau of the Census.

WISCONSIN

Lee Martinson
Senior Housing Planner/Information Specialist
Division of Housing and Community Services
Department of Development
123 W. Washington Avenue
P.O. Box 7970
Madison, WI 53707
608/266-5363

Wisconsin Housing Information System (HIS) maintained at the above address provides current information on housing conditions and needs, especially for low-and moderate income households. A new housing plan to be completed in March 1983 will give information on population, housing stock, and household characteristics; future population and housing growth; and other data useful in planning.

Wisconsin Housing Finance Authority
P. O. Box 1728
Madison, WI 53701
608/266-7884

5. Additional Sources of Population and Housing Data

- City/county planning departments and commissions
- County Assessors' offices
- Township clerks
- School districts
- Chambers of commerce
- 208 agencies
- Facilities planners
- Local college geography departments
- State bureaus of statistics
- Building permit data
- Municipal tax records
- Utility connections
- State and local historical society publications for historic population trends
- Local realty boards
- Local postal service facilities.

B. LAND USE

1. National and Regional Sources

Soil Conservation Service
Inventory and Monitoring Division
U.S. Dept. of Agriculture
P. O. Box 2890
Washington, D.C. 20013
202/447-5424

The Inventory and Monitoring Division collects and disseminates data on land quality, conservation needs, and land use for selected points in most counties in the U.S. The data are stored in machine-readable files. The primary products of the Division are the Conservation Needs Inventory (CNI), the Potential Cropland Study, and the Natural Resources Inventories. Included are county, state, and national data files on land use, land capability, conservation treatment needs, wind erosion, prime farmlands, potential for new cropland, and flood-prone areas. Input is obtained from field data collected at randomly selected primary sample units in every county of the U.S., with the exception of lands owned by the federal government. Tape copies and computerized searching of the machine-readable files are available at cost from:

Iowa State University Statistical Laboratory
Ames, IA 50011

Information on parkland and recreational areas may be obtained from:

National Park Service (NPS)
U.S. Department of the Interior
Washington, D.C. 20240
202/343-7394

The NPS regional office covering the Midwest is:

NPS Midwest Regional Office
1709n Jackson St.
Omaha, NE 68102

Information on federal lands may be obtained from:

Bureau of Land Management
U.S. Dept. of the Interior
18th & C Sts., N.W.

Washington, D.C. 20240
202/343-5994

Land use data may also be obtained from the Bureau of the Census (agricultural Census data), the U.S. Forest Service and the Soil Conservation Service (forest and agricultural acreages), the Fish & Wildlife Service and the Forest Service (recreational areas), and the Bureau of Economic Analysis (projections of industrial development).

Much valuable information may also be obtained on present and future uses of land from regional planning commissions and state planning departments. This information includes industrial and commercial development, uses of under-developed and vacant land, sensitive and hazardous areas, farmland preservation, recreational open space, floodplain and wetlands management, and other activities that may affect the degree and location of future growth. This information may be obtained from regional land use plans, transportation plans, water and sewer plans, capital improvement plans, 208 plans (drainage basin studies), and recreation and open space plans. In addition, regional and state planning agencies can often furnish current population and housing information, as well as data in almost every other category covered herein.

2. Regional Planning Councils

ILLINOIS

Southern Five Regional Planning District
and Development Commission
202 South St.
Anna, IL 62906
618/833-2106

Barrington Council of Governments
132 W. Station
Barrington, IL 60010
312/381-7871

Belvidere-Boon County Regional Planning Commission
613 North Main St.
Belvidere, IL 61008
815/544-5271

McLean County Regional Planining Commission (M)
Illinois House, Suite 201

297 West Jefferson Street
Bloomington, IL 61701
309/828-4331

Greater Egypt Regional Planning and
Development Commission
P. O. Box 3160
Carbondale, IL 62901
618/549-3306

West Central Illinois Valley Regional
Planning Commission (M)
209 North East Street
Carlinville, IL 62626
217/854-9642

Coles County Regional Planning Commission
P. O. Box 471
701 Monroe
Charleston, IL 61920
217/348-0521

Council of Governments of Cook County
400 West Madison St.
Chicago, IL 60606
312/454-0400

Northeastern Illinois Planning Commission (M)
400 West Madison Street
Chicago, IL 60606
312/454-0400

Illinois-Indiana Bi-State Commission (M)
One East Wacker Drive, Suite 3630
Chicago, IL 60601
312/467-4612

Southwestern Illinois Metropolitan
and Regional Planning Commission
203 West Main Street
Collinsville, IL 62234
618/344-4250

Macon County Regional Planning Commission
253 East Wood St.
506 County Bldg.
Decatur, IL 62523

Tri-County Regional Planning Commission
P. O. Box 220
East Peoria, IL 61611
309/694-4391

Dukane Valley Council
719 Batavia Ave.
Geneva, IL 60134
312/232-9220

Greater Wabash Regional Planning Commission (M)
100 South Court Street
Grayville, IL 62844
618/375-2282

Southeastern Illinois Regional Planning
and Development Commission
206 Harrisburg National Bank Bldg.
Harrisburg, IL 62946
618/252-7463

Will County Regional Planning Commission
501 Ella Ave.
Joliet, IL 60433
815/727-8767

Kankakee County Regional Planning Commission
470 East Merchant St.
Kankakee, IL 60901
815/937-2940

Logan County Regional Planning Commission
529 South McLean St.
Lincoln, IL 62656
217/732-8835

Western Illinois Regional Council (M)
223 South Randolph
Macomb, IL 61455
309/837-3941

Grundy County Regional Planning Commission
Grundy County Court House
Morris, IL 60450
815/942-4412

Northwest Municipal Conference (M)
100 S. Emerson St.
Mount Prospect, IL 60056
312/253-6323

Vermilion County Regional Planning Commission
R.R. 1, Box 261
Oakwood, IL 61858
217/446-8971

Embarras Regional Planning and Development Commission
P. O. Box 362
Olney, IL 62450
618/395-2151

North Central Illinois Council of Governments
O. O. Box 206
400 N. Main
Princeton, IL 61356
815/875-3396

Two Rivers Regional Council of Public Officials (M)
Franklin Square
4th and State Sts.
217/224-8171

Bi-State Metropolitan Planning Commission (M)
1504 Third Ave.
Rock Island, IL 61201
309/793-6300

Rock Valley Metropolitan Council (M)
400 West State St., Room 702
Rockford, IL 61101
815/963-6010

South Central Illinois Regional Planning
and Development Commission (M)
Marion County Public Service Bldg.
200 E. Schwartz
Salem, IL 62881
618/548-4234

Springfield-Sangamon County Regional
Planning Commission
703 Myers Bldg.
1 West Old State Capitol Plaza
Springfield, IL 62701

Moultrie County Regional Planning Commission
Courthouse
Sullivan, IL 61951
217/728-7922

DeKalb County Planning Commission
County Courthouse Annex
104 N. Main
Sycamore, IL 60178

Champaign County Regional Planning Commission
P. O. Box 339
Urbana, IL 61801
217/328-3313

Lake County Regional Planning Commission
Room A-803, County Administration Bldg.
Waukegan, IL 60085
312/689-6350

DuPage County Regional Planning Commission
421 N. County Farm Rd.
Wheaton, IL 60187
312/682-7230

McHenry County Regional Planning Commission
2200 North Seminary Ave.
Woodstock, IL 60098
815/338-2040, Ext. 140

INDIANA

Madison County Council of Governments
Government Center
Anderson, IN 46016
317/646-9338

Region XI Development Commission (M)
P. O. Box 904
2576 East 25th St.
Columbus, IN 47201
812/372-9989

Region Nine Development Commission
P. O. Box 222
Connersville, IN 47331
317/825-0524

Southwestern Indiana and Kentucky Regional
Council of Governments (M)
Administration Bldg., Room 314
Civic Center Complex
Evansville, IN 47708
812/426-5117, 5118

Northeastern Indiana Regional Coordinating
Council (M)
City-County Bldg., Room 640
One Main St.
Fort Wayne, IN 46802
219/423-7309

Kankakee-Iroquois Regional Planning Commission
Route 1, Box A-51
Francesville, IN 47946
219/567-9432

Northwestern Indiana Regional Planning Commission (M)
8149 Kennedy Ave.
Highland, IN 46322
219/923-1060

Indiana 15 Regional Planning Commission (M)
511 Fourth St.
P. O. Box 70
Huntingburg, IN 47542
812/683-4647

Indiana Heartland Coordinating Commission
7212 North Shadeland Ave.
Suite 120
Indianapolis, IN 46250
317/849-4628

Region IIIA Development and Regional
Planning Commission (M)
119 W. Mitchell
Kendallville, IN 46755
219/347-4714

Region IV Development Commission
301 Columbia St.
Lafayette, IN 47901
317/742-4402

Southern Indiana Development Commission
P. O. Box 442
Loogootee, IN 47553
812/295-3707

Region VI Planning and Development Commission
207 North Talley Ave.
Muncie, IN 47303
317/285-6252

River Hills Regional Planning Commission (M)
c/O Indiana University Southeast
4201 Grantline Road
New Albany, IN 47150
812/945-2731, Ext. 346

Quabache Regional Planning Commission
Singer Ross Bldg.
25 Court St.
Peru, IN 46970
317/472-4391

Michiana Area Council of Governments (M)
1120 County-City Building
South Bend, IN 46601
219/287-1829

West Central Indiana Economic
Development District (M)
P.O. Box 359

121 S. 3rd St.
Terre Haute, IN 47808
812/238-1561

Southeastern Indiana Regional
Planning Commission (M)
P.O. Box 127
Versailles, IN 47042
812/689-5505

MICHIGAN

Southeast Michigan Council of Governments (M)
1249 Washington Blvd.
Book Building, Suite 800
Detroit, MI 48226
313/961-4266

Central Upper Peninsula Planning and
Development Regional Commission (M)
2415 14th Ave., South
Escanaba, MI 49829
906/786-9234

Genesee-Lapeer-Shiawassee Region V
Planning and Development Commission (M)
1602 West Third Ave.
Flint, MI 48504
313/234-0340

Southcentral Michigan Planning Council (M)
72 E. Michigan Ave.
Galesburg, MI 49053
616/665-4221

Northeast Michigan Council of Governments (M)
P.O. Box 457
114 N Court
Gaylord, MI 49735
517/732-3551

West Michigan Regional Planning Commission (M)
60 Monroe at Ionia
1204 People's Bldg.
Grand Rapids, MI 49503
616/454-9375

Western Upper Peninsula Planning
and Development Region (M)
P. O. Box 365
Houghton, MI 49931
906/482-7205

Region II Planning Commission (M)
120 West Michigan Ave.
Jackson County Tower
Jackson, MI 49201
517/788-4426

Tri-County Regional Planning Commission (M)
913 W. Holmes Road, Suite 201
Lansing, MI 48901
517/393-0342

West Michigan Shoreline Regional
Development Commission (M)
500 Hackley Bank Bldg.
Muskegon Mall
Muskegon, MI 49440
616/722-7878

East Central Michigan Planning
and Development Region (M)
P. O. Box 930
Saginaw, MI 48606
517/752-0100

Eastern Upper Peninsula Regional Planning
and Development Commission (M)
426 Ashmun St.
Sault Ste. Marie, MI 49783
906/635-1581

Southwestern Michigan Regional
Planning Commission
2907 Division St.
St. Joseph, MI 49085
616/983-1529

Northwest Michigan Regional Planning
and Development Commission (M)
160 East State St.
Traverse City, MI 49684
616/946-5922

MINNESOTA

Upper Minnesota Valley Regional
Development Commission (M)
323 West Schlieman Ave.
Appleton, MN 56208
612/289-1981

Austin-Mower County Areawide
Planning Organization
Mower County Courthouse
Austin, MN 55912
507/433-1846

Headwaters Regional Development Commission
P.O. Box 586
722 15th St.
Bemidji, MN 56601
218/751-3108

Northwest Regional Development Commission
425 Woodland Ave.
Crookston, MN 56716
218/281-1396

Arrowhead Regional Development Commission
200 Arrowhead Place
Duluth, MN 55802
218/722-5545

West Central Regional Development Commission
Fergus Falls Community College
Fergus Falls, MN 56537
218/739-3356

Minnesota Valley Council of Governments
202 East Jackson St.
Mankota, MN 56001
507/625-3161

Region IX Development Commission (M)
P. O. Boc 3367
120 S. Broad
Mankota, MN 56001
507/387-5643

Fargo-Moorhead Metropolitan Council of Governments
44 Foss Lane
Moorhead, MN 56560
218/233-2704

East Central Regional Development Commission
119 South Lake St.
Mora MN 55051
612/679-4065

Southeastern Minnesota Regional
Development Commission (M)
2200 Second St., S.W.
Rochester, MN 55901
507/281-4051

Rochester-Olmsted Council of Governments
1421 Third Ave., S.E.
Rochester, MN 55901
507/285-8236

Southwest Regional Development Commission (M)
P. O. Box 265
Slayton, MN 56172
507/836-8549

Central Minnesota Regional Development Commission
2700 1st St., North
St. Cloud, MN 56301
612/253-7870

St. Cloud Area Planning Organization
46 North 28th Ave.
St. Cloud, MN 56301
612/252-7568

Metropolitan Inter-County Association (M)
2305 Ford Parkway, Suite 103
St. Paul, MN 55116
612/690-2282

Metropolitan Council of the
Twin Cities Area (M)
300 Metro Square Bldg.
St. Paul, MN 55101
612/291-6454

Region V Regional Development Commission
611 Iowa Avenue
Staples, MN 56479
218/894-3233

Six East Regional Development Commission
311 West Sixth St.
Willmar, MN 56201
612/235-8504

OHIO

Northeast Ohio Four County Regional
Planning and Development Organization (M)
Delaware Bldg., Suite 300
137 South Main St.
Akron, OH 44309
216/253-4196

Summit County Council of Governments (M)
Ohio Bldg., Room 210
175 South Main
Akron, OH 44308
216/253-7101

Ohio Mid Eastern Governments Association (M)
326 Highland Avenue
Cambridge, Oh 43725
614/439-4471

Stark County Regional Planning Commission
511 County Office Building
Canton, OH 44702
216/454-5651

Ohio-Kentucky-Indiana Regional
Council of Governments (M)
426 East Fourth St.
Cincinnati, OH 45202
513/621-7060

Northeast Ohio Areawide Coordinating Agency (M)
Playhouse Square
1501 Euclide Ave.
Cleveland, OH 44115
216/241-2414

Mid-Ohio Regional Planning Commission (M)
514 South High St.
Columbus, OH 43215
614/228-2663

Coshocton County Regional Planning Commission
124 Chestnut St.
Coshocton, OH 43812
614/622-5411

Miami Valley Regional Planning Commission (M)
117 South Main St., Suite 200
Dayton, OH 45402
513/223-6323

Maumee Valley Resource Conservation
Development and Planning Organization (M)
1012 Ralston Ave.
Definance, OH 43512
419/782-4548

Delaware County Regional Planning Commission
110½ North Franklin St.
Delaware, OH 43015
614/369-8761, Ext. 292

Lake County Council of Governments
37549 Willow Drive
East Lake, Oh 44094
216/946-6045

Logan-Union-Champaign Region Planning Commission
P. O. Box 141
East Liberty, OH 43319
513/666-3431

Hancock Regional Planning Commission
223 South Main Street
Findlay, OH 45840
419/422-3322

Lima-Allen County Regional Planning Commission
212 North Elizabeth St.
Lima, OH 45801
419/228-1836

Columbiana County Planning Commission
110 Nelson Ave.
Lisbon, OH 44432
216/424-9511, Ext. 278

Richland County Regional Commission
35 North Park St.
Mansfield, OH 44902
419/522-9454

Buckeye Hills-Hocking Valley Regional
Development District (M)
St. Clair Bldg., Suite 410
216 Putnam St.
Marietta, Oh 45750
614/374-9436

Marion County Regional Planning Commission
169½ East Center St.
Marion, OH 43302
614/387-6188

Tuscarawas County Regional Planning Commission
172 N. Broadway
New Philadelphia, OH 44663
216/364-8811, Ext. 246

Licking County Regional Planning Commission
743 East Main St.
Newark, OH 43055
614/345-1577

Huron County Regional Planning Commission
180 Milan Ave.
Norwalk, OH 44857
419/668-6193

North Star Council of Governments
Huron County Administration Bldg.
180 Milan Ave.
419/668-2911

Ohio Valley Regional Development Commission (M)
740 Second St.

Portsmouth, OH 45662
614/354-7795

Erie Regional Planning Commission
2121 Cleveland Road
Sandusky, OH 44870
419/625-9062

Clark County-Springfield Regional Planning Commission
25 West Pleasent St.
Springfield, OH 45506
513/325-4665

Brook-Hancock-Jefferson Metropolitan Planning Commission (M)
814 Adams St.
Steubenville, OH 43952
614/282-3685

Jefferson County Regional Planning Commission
P. O. Box 383
Steubenville, OH 43952
614/283-4111, Ext. 229

Toledo Metropolitan Area Council of Governments (M)
The Davis Bldg.
123 Michigan St.
Toledo, OH 43624
419/241-9155

Eastgate Development and Transportation Agency
130 Javit Court
Youngstown, OH 44515
216/793-3282

WISCONSIN

West Central Wisconsin Regional Planning Commission
124½ Graham Ave.
Eau Claire, WI 54701
715/836-2918

Bay-Lake Regional Planning Commission
S. E. Bldg., Suite 450
University of Wisconsin-Green Bay
Green Bay, WI 54302
414/465-2135

Mississippi River Regional Planning Commission
400 N. Fourth
Courthouse, Room 110
La Crosse, WI 54601
608/785-9396

Dane County Regional Planning Commission (M)
City-County Bldg., Room 114
Madison, WI 53709
608/266-4137

East Central Wisconsin Regional Planning Commission
140 Main St.
Menasha, WI 54952
414/729-1100

Southwestern Wisconsin Regional Planning Commission
426 Karrmann Library
725 West Main St.
Platteville, WI 53818
608/342-1214

Northwest Regional Planning Commission
302 Walnut St.
Spooner, WI 54801
715/635-2197

Southeastern Wisconsin Regional Planning Commission
P. O. Box 769
916 North East Ave.
Waukesha, WI 53186
414/547-6721

North Central Wisconsin Regional Planning Commission (M)
901 Cherry St.
Wausau, WI 54401
715/675-2345

3. State Sources

ILLINOIS

Department of Commerce and Community Affairs
222 S. College St.
Springfield, IL 62706
217/792-7500

Commission for Economic Development
222 S. College St., Room 203
Springfield, IL 62706
217/782-2874

INDIANA

Economic Development Group
Department of Commerce
440 N. Meridian St.
Indianapolis, IN 46204
317/232-8854

State Planning Services Agency
300 Harrison Bldg.
143 W. Market St.
Indianapolis, IN 46204
317/232-1470

MICHIGAN

Office of Economic Development
Department of Commerce
P. O. Box 30225
Lansing, MI 48909
517/373-3530

MINNESOTA

Office of Local and Urban Affairs
State Planning Agency
200 Capitol Square Bldg.
550 Cedar St.
St. Paul, MN 55101
612/296-9000

Department of Economic Development
Hanover Bldg.
480 Cedar St.
St. Paul, MN 55101
612/296-2755

Minnesota Land Management Information Center
Minnesota Department of Energy, Planning
and Development
Rm. LL45, Metro Square Bldg.
7th and Robert Sts.
St. Paul, MN 55101
612/296-1211

The Minnesota Land Management Information Center, a service bureau operating the Minnesota Land Management Information Systems (MLMIS), provides land use and natural resource data collection, storage, and analysis for governmental agencies in Minnesota. Collected data are referenced by longitude, latitude, and UTM (Universal Traverse Mercator), based on the geocoding schemes used by the U.S. Land Survey and Minor Civil Divisions. Scope of the data includes Minnesota land use; geocoding; watersheds lakes and lakeshore development; soils; forest cover; and land suitability analysis. The following computerized data are maintained at 40-acre resolution for the state of Minnesota: Land use 1969, public ownership by agency, 1960 and 1970 minor civil division numbers, soil type, geomorphic region, forest type, highway orientation, water orientation, watersheds, irrigation activity, historical and archaeological sites, school districts, and recreation sites. Statewide files are held not only for 40-acre resolution with 70 variables, but also for 5-kilometer resolution with 200 variables. MLMIS publishes a newsletter, maps and atlases, reports, manuals, technical reports, papers, and theses. Additional services include information systems design, and advisory and consulting services.

OHIO

Roger D. Hubbell, Chief
Office of Outdoor Recreation Facilities
Ohio DNR
Fountain Square
Columbus, Oh 43224
614/265-6395
(Information on the State Comprehensive Outdoor Recreation Plan and recreational facilities)

Economic Development Division
Department of Economic and Community Development
State Office Towers, 23rd Fl.
30 E. Broad St.
Columbus, Oh 43215
614/466-8831

WISCONSIN

Don Pokorski
Division of Housing and Community Services
Department of Development
125 W. Washington Avenue
P.O. Box 7970
Madison, WI 53707
608/266-3751
(Information on municipal annexations, land subdivisions activity, and county farmland preservation)

Department of Local Affairs and Development
P. O. Box 7970
Madison, WI 53707
608/266-1018

Division of State Executive Budget and Planning
Department of Administration
101 S. Webster St.
Madison, WI 53702
608/266-1035

VI. ARCHAEOLOGICAL AND HISTORIC RESOURCES

A. NATIONAL REGISTER OF HISTORIC PLACES

U.S. Department of the Interior
National Park Service
440 G St., N.W.
Washington, D.C. 20243
202/343-6401

The National Register is the primary source of information on identified archaeological and historic resources in the U.S. The Register is a computer-readable inventory of districts, sites, buildings, structures, and objects determined to be worthy of preservation. Properties meeting National Register criteria are nominated by State Historic Preservation Officers (SHPO), or, in the case of federal property, by representatives appointed by agency heads. Final decisions are made by the Secretary of the Interior. The Register is also available from the GPO in the form of a printed 2-volume directory with updates. The 2-volume directory is cumulative through 1978, and subsequent annual compilations, normally published the first Tuesday in February beginning in 1979, must be consulted for an update of listings. Additions to the National Register may be found by consulting the Federal Register published the first Tuesday of the month. The National Register covers all historic areas in the National Park System and properties eligible for designation as National Historic Landmarks. Approximately 25,000 properties are registered.

The SHPO should be consulted to identify all properties potentially eligible for listing in the National Register within the primary impact area. Regulations of the Advisory Council on Historic Preservation apply if the sites are determined to be eligible. The Advisory Council is an independent Federal agency, separate from the National Park Service, and is the major governmental policy advisor in the field of archaeological and historic preservation.

B. STATE HISTORIC PRESERVATION OFFICES

ILLINOIS

Division of Lands and Historic Sites
Department of Conservation
405 E. Washington St.
Springfield, IL 62706
217/782-3340

INDIANA

Department of Natural Resources
608 State Office Bldg.
100 N. Senate Ave.
Indianapolis, IN 46204

MICHIGAN

Dr. John R. Halsey
State Archaeologist and Environmental
Review Coordinator
History Division
Department of State
208 N. Capitol St.
Lansing, MI 48918
517/373-0510

MINNESOTA

Historical Society
Historical Bldg.
690 Cedar St.
St. Paul, MN 55101
612/296-2747

OHIO

Division of Historic Preservation
Ohio Historical Society
Interstate 71 at 17th Ave.
Columbus, OH 43211
614/466-1500

The Ohio Historical Society also maintains five regional offices that provide information and guidance to local governments on historic preservation and their respective preservation organizations. The regional representatives coordinate historic preservation activities within their respective regions, although they do not provide surveying or inventorying of historic sites or structures. The regional offices and representatives are as follows:

Ms. Gloria Scott
Northwest Office
Ohio Historical Society
Center for Archival Collections
Jerome Library
Bowling Green State University
Bowling Green, OH 43403
419/372-2411

Mr. Jeffrey Brown
Northeast Office
Ohio Historical Society
Stark County Regional Planning Commission
County Office Building
Canton, OH 44702
216/454-5651

Ms. Maryanne Brown
Southwest Office
Ohio Historical Society
Wright State University
Dayton, OH 45435
513/873-2815

Ms. Kathleen Kelley
Central South Central Office
Ohio Historical Society
Columbus Landmarks Foundation
22 N. Front St.
Columbus, OH 43215
614/221-0227

Mr. Chris Witner
Southeast Office
Ohio Historical Society
Ohio University
Department of History
Athens, OH 45701
614/594-6578

WISCONSIN

State Historical Society of Wisconsin
816 State St.
Madison, WI 53706
608/262-3266

C. NATIONAL HISTORICAL PUBLICATIONS AND RECORDS COMMISSION (NHPRC)

NHPRC Data Base on Historical Records in the United States
National Archives
Washington, D.C. 20408
202/724-1630

The NHPRC is a Federal commission supported by the National Archives and Records Service of the U.S. General Service Administration. The NHPRC Data Base contains information on archives and manuscripts held in the U.S. It is used to produce the Directory of Archives and Manuscripts Repositories, and includes descriptions of all archival and manuscript materials housed in repositories in the U.S. Examples of such materials are collections of personal papers, corporate records, photographs, original motion pictures and sound recordings, machine-readable files, and oral history tapes. Information is derived from a variety of sources, including questionnaires, published descriptions of archives and manuscript collections, and survey forms and data files submitted by field workers on cooperating projects. The Commission publishes a Directory of Archives and Manuscript Repositories, available from the above address. The Commission has also supported cooperative database development in the states of Wisconsin, Minnesota, and Illinois, and is headquartered in the Wisconsin State Historical Society.

D. OTHER SOURCES OF HISTORICAL AND ARCHAEOLOGICAL DATA

- Great Lakes Historical Society
  480 Main St.
  Vermilion, OH 44089
  216/967-3457

- Ms. Anne Manuell
  Cultural Resources Coordinator
  Division of Historic Sites
  405 East Washington Street
  Springfield, IL 62706

- Where to Look: A Guide to Preservation Information. Advisory Council on Historic Preservation. Available from the Advisory Council or from the Superintendent of Documents, US Government Printing Office, Washington, D.C. 20402

ILLINOIS

1980 ADAMS
1975 CARROLL (STATE)
1980 CLARK
*1902 CLAY
*1902 CLINTON
1978 DE KALB
1971 DOUGLAS
1979 DUPAGE COUNTY AND PART OF COOK
1972 EDWARDS AND RICHLAND
1969 GALLATIN
1974 GREENE
1980 GRUNDY
1956 HENDERSON (STATE)
1979 JACKSON
1966 JERSEY (STATE)
*1903 JOHNSON
1964 JOHNSON (STATE)
1979 KANE
1979 KANKAKEE
1978 KENDALL
*1903 KNOX
1970 LAKE
1972 LA SALLE (STATE)
1956 LAWRENCE (STATE)
1974 LOGAN
1965 MCHENRY (STATE)
*1903 MCLEAN
1953 MENARD (STATE)
1969 MONTGOMERY
*1904 O'FALLON AREA
1980 OGLE
1975 POPE, HARDIN AND MASSAC
1968 PULASKI AND ALEXANDER
1977 ROCK ISLAND
1978 SALINE
*1903 SANGAMON
1980 SANGAMON
*1902 ST. CLAIR
1978 ST. CLAIR
1976 STEPHENSON (STATE)
*1902 TAZEWELL
1979 UNION
1964 WABASH
*1912 WILL
1962 WILL (STATE)
1959 WILLIAMSON (STATE)
*1903 WINNEBAGO
1980 WINNEBAGO AND BOONE

INDIANA

1921 ADAMS
*1908 ALLEN
1969 ALLEN
1947 BARTHOLOMEW
1976 BARTHOLOMEW
1916 BENTON
*1928 BLACKFORD
*1912 BOONE
1975 BOONE
*1904 BOONEVILLE AREA
1946 BROWN
1958 CARROLL
*1955 CASS
1981 CASS
1974 CLARK AND FLOYD
1922 CLAY
*1914 CLINTON
1980 CLINTON
1975 CRAWFORD
1974 DAVIESS
1981 DEARBORN AND OHIO
1910 DECATUR
*1913 DELAWARE
1972 DELAWARE
1937 DUBOIS
1980 DUBOIS
*1914 ELKHART
1974 ELKHART
1960 FAYETTE AND UNION
1966 FOUNTAIN
1950 FRANKLIN
1946 FULTON
1922 GIBSON
*1915 GRANT
*1906 GREENE
*1912 HAMILTON
1978 HAMILTON
1925 HANCOCK
1978 HANCOCK
1975 HARRISON
1913 HENDRICKS
1974 HENDRICKS
1971 HOWARD
1940 JENNINGS
1976 JENNINGS
*1948 JOHNSON
1979 JOHNSON
1943 KNOX
1981 KNOX
*1922 KOSCIUSKO
1980 LAGRANGE
1944 LA PORTE
*1917 LAKE
1972 LAKE
*1922 LAWRENCE
*1903 MADISON
1967 MADISON
*1907 MARION
1978 MARION
*1904 MARSHALL
1980 MARSHALL
1946 MARTIN
1927 MIAMI
1979 MIAMI
*1922 MONROE
1981 MONROE
*1912 MONTGOMERY
1950 MORGAN
1981 MORGAN
*1905 NEWTON
*1955 NEWTON
*1953 NOBLE
1977 NOBLE
1930 OHIO AND SWITZERLAND
*1964 OWEN
1967 PARKE
1969 PERRY
1938 PIKE
*1916 PORTER
1981 PORTER
*1902 POSEY
1979 POSEY
1968 PULASKI
1925 PUTNAM
1981 PUTNAM
1931 RANDOLPH
*1937 RUSH
*1904 SCOTT
1962 SCOTT
1974 SHELBY
1973 SPENCER
*1950 ST. JOSEPH
1977 ST. JOSEPH
*1915 STARKE
1940 STEUBEN
1981 STEUBEN
1971 SULLIVAN
*1905 TIPPECANOE
1959 TIPPECANOE
*1912 TIPTON
1944 VANDERBURGH
1976 VANDERBURGH
1930 VERMILLION
1978 VERMILLION
1974 VIGO
*1914 WARREN
1979 WARRICK
1939 WASHINGTON
1925 WAYNE
*1915 WELLS
*1915 WHITE

MICHIGAN

1929 ALGER
*1901 ALLEGAN
*1904 ALMA AREA
1924 ALPENA
1923 ANTRIM
1978 ANTRIM
1967 ARENAC
1924 BARRY
1931 BAY
1980 BAY
*1902 BERRIEN
1980 BERRIEN
*1928 BRANCH
*1916 CALHOUN
*1906 CASS
1974 CHARLEVOIX
1939 CHEBOYGAN
1927 CHIPPEWA
1979 CLARE
1942 CLINTON
1978 CLINTON
1927 CRAWFORD
1977 DELTA AND HIAWATHA NATIONAL FOREST
*1930 EATON
1978 EATON
1973 EMMET
*1912 GENESEE
1972 GENESEE
1972 GLADWIN
1966 GRAND TRAVERSE
1979 GRATIOT
1924 HILLSDALE
1980 HURON
1941 INGHAM
1979 INGHAM
1967 IONIA
1937 IRON
1925 ISABELLA
1926 JACKSON
1981 JACKSON
*1922 KALAMAZOO
1979 KALAMAZOO
1927 KALKASKA
1926 KENT
1972 LAPEER
1973 LEELANAU
1961 LENAWEE
*1923 LIVINGSTON
1974 LIVINGSTON
1929 LUCE
*1923 MACOMB
1971 MACOMB
1922 MANISTEE
1939 MASON
1927 MECOSTA
1925 MENOMINEE
1950 MIDLAND

* OUT OF PRINT ; NOT AVAILABLE FOR DISTRIBUTION

1979 MIDLAND
1981 MCNRGE
1960 MCNTCALM
1930 MCNTMORENCY
•1904 MUNISING AREA
•1924 MUSKEGCN
1958 MUSKEGCN
1951 NEWAYGO
1938 CCEANA
1923 OGEMAW
1969 CSCEOLA
1931 CSCCDA
•1922 CTTAWA
1972 CTTAWA
•1904 GWOSSC AREA
•1905 GXFCRC AREA
•1903 PONTIAC AREA
•1940 PRESCUE ISLE
•1921 RECCNNAISSANCE ONTONAGON
1924 ROSCGMMGN
1938 SAGINAW
•1904 SAGINAW AREA
1961 SANILAC
1939 SCHCCLCRAFT
1974 SHIAWASSEE
•1929 ST. CLAIR
1974 ST. CLAIR
•1921 ST. JCSEPH
1926 TUSCOLA
•1922 VAN BUREN
1930 WASHTENAW
1977 WASHTENAW
1977 WAYNE AREA
•1908 WEXFORD

MINNESOTA

•1916 ANOKA
1977 ANOKA
1977 BENTCN
•1906 BLUE EARTH
1979 BLUE EARTH
1978 CARLTCN
•1905 CARLTCN AREA
1968 CARVER
1979 COTTCNWOOD
•1906 CROCKSTCN AREA
1965 CRCW WING
1960 DAKCTA
1961 DODGE
1975 DOUGLAS
1957 FARIBAULT
1958 FILLMCRE
1980 FREEBCRN
•1913 GOODHUE
1976 GOODHUE
1978 GRANT
•1929 HENNEPIN
1974 HENNEPIN
•1929 HCUSTCN
1930 HUBBARD
1958 ISANTI
•1923 JACKSCN
•1939 KAKABEC
1978 KAWISHIWI AREA
1979 KITTSCN
•1924 LAC CUI PARLE
•1926 LAKE CF THE WOODS (RECCNNAISSANCE)
•1954 LE SUEUR
1970 LINCCLN
1979 LYON
•1903 MARSHALL AREA
•1955 MCLECD
•1927 MILLE LACS
•1958 NICCLLET
1975 NCBLES
1974 NORMAN
•1923 OLMSTED
1980 OLMSTED
•1914 PENNINGTCN
•1941 PINE
1976 PIPESTONE
1972 PCPE
•1914 RAMSEY
•1939 RED RIVER VALLEY AREA
•1909 RICE
1975 RICE
1949 RCCK
1942 RCSEAU
1959 SCOTT
1968 SHERBURNE
1973 STEELE
•1919 STEVENS
1971 STEVENS
1973 SWIFT
1965 WABASHA
•1926 WADENA
1965 WASECA
1980 WASHINGTON-RAMSEY
1968 WRIGHT
1981 YELLOW MEDICINE

CHIC

•1938 ADAMS
1965 ALLEN
1980 ASHLAND
1973 ASHTABULA
•1903 ASHTABULA AREA
•1938 ATHENS
•1909 AUGLAIZE
•1927 BELMONT
1981 BELMONT
•1930 BROWN
•1927 BUTLER
1980 BUTLER
1971 CHAMPAIGN
1958 CLARK
•1923 CLERMCNT
1975 CLERMCNT
•1905 CLEVELAND AREA
1962 CLINTON
1968 COLUMBIANA
•1902 COLUMBUS AREA
•1904 COSHOCTCN
1979 CRAWFORD
1981 CUYAHOGA
1969 DELAWARE
1971 ERIE
1960 FAIRFIELD
1973 FAYETTE
1980 FRANKLIN
•1922 FULTCN
•1915 GEAUGA
1978 GREENE
•1915 HAMILTCN
1973 HANCCCK
1974 HENRY
1977 HIGHLAND
1955 HURON
•1925 LAKE
1979 LAKE
•1938 LICKING
•1939 LOGAN
1980 LOGAN
1976 LCRAIN
•1934 LUCAS
1980 LUCAS
1981 MADISCN
•1917 MAHCNING
1971 MAHCNING
•1916 MARICN
1977 MEDINA
•1906 MEIGS
1979 MERCER
•1916 MIAMI
1978 MIAMI
1974 MONRCE
•1900 MCNTGCMERY
1976 MONTGCMERY
•1925 MUSKINGUM
•1928 OTTAWA
•1914 PAULDING
1960 PAULDING
1980 PICKAWAY
•1914 PCRTAGE
1978 PCRTAGE
1969 PREBLE
•1930 PUTNAM
1974 PUTNAM
•1912 RECCNNAISSANCE OF STATE CF CHIC
1975 RICHLAND
1967 RCSS
•1917 SANDUSKY
•1940 SCIGTC
1980 SENECA
1980 SHELBY
•1913 STARK
1971 STARK
1974 SUMMIT
•1902 TCLEDC AREA
•1914 TRUMBULL
1954 TUSCARAWAS
1975 UNICN
1972 VAN WERT
•1938 VINTCN
1973 WARREN
•1926 WASHINGTON
1977 WASHINGTON
•1905 WESTERVILLE AREA
1979 WILLIAMS
1966 WOOD
•1904 WOOSTER AREA

WISCCNSIN

•1920 ADAMS
1980 ADAMS
1958 BARRCN
•1910 BAYFIELD
1961 BAYFIELD
•1929 BRCWN
1974 BRCWN
•1913 BUFFALO
1962 BUFFALO
•1925 CALUMET
1980 CALUMET AND MANITOWOC
•1911 CCLUMBIA
1978 CCLUMBIA
•1930 CRAWFCRD
1961 CRAWFCRD
•1913 DANE
1978 DANE
1980 DODGE
•1916 DCCR
1978 DOOR
1975 DUNN
1977 EAU CLAIRE
•1911 FOND DU LAC

• CUT OF PRINT ; NOT AVAILABLE FOR DISTRIBUTION

APPENDIX 16-B

GUIDELINES FOR A MONITORING WELL PROGRAM

BASICS OF GROUND WATER MONITORING SYSTEM DESIGN

David M. Nielsen, C.P.G., Senior Hydrogeologist
IEP, Inc. Consulting Environmental Scientists
Worthington, Ohio

I. Factors to Consider in Ground Water Monitoring System Design
   A. Objectives of the Investigation
   B. Geography of the Area
   C. Geologic/Hydrogeologic Characteristics
   D. Characteristics of Potential Contaminants
   E. Anthropogenic Influences

II. Defining the Objectives of the Ground Water Monitoring Program
   A. Ground Water Quality Monitoring
      1. Detection Monitoring
         a. Monitoring for the Presence of Contaminants in Ground Water
      2. Assessment Monitoring
         a. Monitoring Rate and Direction of Contaminant Movement
         b. Monitoring Extent of Contamination and Concentrations of Contaminants
      3. Monitoring Effectiveness of Corrective Actions

   B. Ground Water Level Monitoring
      1. Natural Variations in Water Levels
      2. Man-Induced Variations in Water Levels

III. Evaluating Geographic Conditions
   A. Analyze Topography
      1. Locate Hills, Swales, other Natural Features
      2. Locate Roads, Railroads, other Man-Made Features

   B. Analyze Surface Hydrology
      1. Locate Surface Drainage Routes
      2. Locate Areas of Potential Ground Water Recharge/Discharge

   C. Analyze Climatic Conditions
      1. Determine Water Budget
         a. Precipitation
         b. Evapotranspiration
      2. Establish Temporal Variations in Climate Conditions

IV. Determining Geologic/Hydrogeologic Characteristics
   A. Types of Geologic Media
      1. Unconsolidated Sedimentary Deposits - Materials derived from the chemical and mechanical breakdown of pre-existing rocks by:
         a. Ice-glacial deposits of clay, silt, sand and gravel
         b. Water-river, lake and ocean deposits of clay, silt, sand and gravel
            1. Examples: alluvial sand/gravel, lacustrine clay, beach sand
         c. Wind-desert, coastal and inland deposits of silt and sand
            1. Examples: loess, sand dunes

2. Consolidated Sedimentary Rocks - lithified sedimentary deposits
    a. Examples: Sandstone, siltstone, shale, conglomerate, limestone, dolomite
3. Metamorphic Rocks - pre-existing rocks altered by heat or pressure
    a. Examples: Slate (shale), quartzite (sandstone), marble (limestone), gneiss (granite)
4. Igneous Rocks - formed by the solidification of molten rock material (magma) either at or beneath the surface
    a. Examples: Granite, basalt, diorite

B. Hydraulic Properties of Geologic Media
1. Porosity - percentage of a geologic medium that is void of solid material
    a. Granular (primary) porosity
        1. sands, gravels, silts, clays (sedimentary)
    b. Fracture or solution (secondary) porosity
        1. sedimentary, metamorphic or igneous rocks
        2. limestone, dolomite, marble
    c. Units: none
    d. Symbol: n
2. Permeability - ability of a geologic medium to transmit fluids (controlled by properties of the medium only)
    a. Units: darcys
    b. Symbol: k
3. Hydraulic Conductivity - characterization of the rate at which a fluid can move through a geologic medium (controlled by properties of both the medium and the fluid; i.e. density, viscosity)
    a. Units: Velocity--cm/sec. or gpd/ft^2
    b. Symbol: K
4. Transmissivity - rate at which fluid is transmitted through a unit width of a geologic medium under a hydraulic gradient (controlled by properties of the medium and the fluid and by the thickness of the medium)
    a. Units: area/time--m^2/day or gpd/ft
    b. Symbol: T
5. Hydraulic Gradient - change in hydraulic pressure in an aquifer with a change in distance.
    a. Units: none
    b. Symbol: I or dh/dl

C. Principles of Flow Through Geologic Media
1. Darcy's Law - the flow rate of a fluid through a porous geologic medium is proportional to the decrease in hydraulic pressure divided by the length of the flowpath

$$V = -K(dh/dl) = Q/A$$

or $Q = -KA(dh/dl)$

(negative sign indicates flow is in direction of decreasing head)

Where V = Velocity
    Q = discharge (volume)
    A = cross-sectional area
    dh/dl = hydraulic gradient

2. Hydraulic head (pressure or potential) - the driving force behind the flow of ground water. Flow is always from areas of high hydraulic head to areas of lower hydraulic head; head decreases along the direction of flow.
    a. Recharge areas - areas in which there are downward components of hydraulic head
    b. Discharge areas - areas in which there are upward components of hydraulic head

D. Types of Aquifers (water-bearing geologic materials)
1. Unconfined - aquifers in which there are confining beds between the zone of saturation and the ground surface; water-table aquifers
2. Confined - aquifers that are overlain by a confining bed that has a significantly lower hydraulic conductivity than the aquifer; artesian aquifers
    a. Piezometric (potentiometric) surface - an imaginary surface coinciding with the hydrostatic pressure level of the water at some point in the aquifer.
3. Interconnected Unconfined/Confined Systems

V. Characteristics of Potential Contaminants
A. Sources of contaminants
1. Municipal Sources
    a. Liquid Wastes
        1. Sewers
        2. Wastewater Treatment Plants
        3. Septic Tanks
    b. Solid Wastes
        1. Landfills and Dumps
2. Industrial Sources
    a. Liquid Wastes
        1. Surface Impoundments (Lagoons, Ponds)
        2. Underground and Above-Ground Tanks and Pipelines
        3. Oil Field Activities (Brine or Drilling Fluid Deposit)
        4. Land Application
        4. Injection Wells
    b. Solid Wastes
        1. Landfills and Dumps
        2. Mine Spoil Piles
3. Agricultural Sources
    a. Liquid/Solid Sources
        1. Fertilizers
        2. Herbicides/Pesticides
        3. Irrigation Return Flow
        4. Animal Wastes (Feedlots)
4. Miscellaneous Sources
    a. Spills and Surface Discharges
    b. Highway Deicing
    c. Saltwater Intrusion
    d. Surface Water Contamination
    e. Faulty Well Construction

B. Contaminant Types and Properties
   1. "Mixers" - those contaminants highly soluble in water, the densities and viscosities of which are similar to water
      a. Methods of Propagation
         1. Advection - movement of solutes with ground water flow with no change in concentration over distance
         2. Hydrodynamic Dispersion - process by which ground water containing a solute is diluted by uncontaminated ground water as it moves through an aquifer; a microscopic phenomenon encountered whenever two fluids with different chemical or physical characteristics come into contact, caused by a combination of:
            a. Mechanical Mixing
            b. Molecular Diffusion
   2. "Floaters" - those contaminants that are immersible (insoluble) in water, and less dense than water (i.e. most petroleum hydrocarbons)
   3. "Sinkers" - those contaminants that are immersible (insoluble) in water, and more dense than water (i.e. many chlorinated organics)

C. Hydrodynamics of Contaminant Movement
   1. Controlling Factors
      a. Aquifer Characteristics
         1. Mineralogy
         2. Hydraulic Properties
      b. Hydrology
         1. Water Balance
         2. Recharge/Discharge Relationships
      c. Contaminant Properties
         1. Chemistry
         2. Density
         3. Viscosity
         4. Reactivity
         5. Potential for Differentiation

D. Methods of Contaminant Attenuation or Retardation
   1. Filtration - removal of suspended solids
   2. Sorption - attraction of ions in solution to solid materials
      a. Adsorption - adherence onto surface of material
      b. Absorption - incorporation into matrix of material
   3. Chemical Processes
      a. Oxidation/Reduction Reactions
      b. Chemical Precipitation/Dissolution
      c. Buffering
      d. Cation Exchange
      e. Volatilization
   4. Biological Processes - metabolism of contaminants or a Heration of contaminant chemistry by naturally occurring microorganisms
      a. Biodegradation
         1. Natural
         2. Enhanced
      b. Biotransformation
   5. Dilution - mixing of contaminant with native ground water due to dispersion

VI. Anthropogenic Influences
   A. Other Potential Contaminant Sources
      1. Neighboring Properties
   B. Pumping or Injection Wells
      1. Pumping/Injection Rates and Schedules
      2. Area(s) of Influence
      3. Production/Injection Zones
   C. Other Influences on Ground Water Flow
      1. Quarries or other Excavations

GROUND-WATER MONITORING SYSTEM CONSIDERATIONS

Discusses factors that should be considered when designing a system for the collection and analysis of water quality data.

by Steve J. Nacht

Introduction

This article discusses a number of generic factors that should be considered in the design of a ground-water monitoring program for the collection and analysis of water quality data. It serves to bring together a number of factors common to most ground-water monitoring programs, such as the definition of objectives, number of samplers required, selection of the analytical laboratory, etc., which, if ignored, can lead to the improper interpretation of data.

In the past few years, considerable attention has been given to the monitoring of ground-water quality. This is the result of legal requirements, the availability of analytical equipment which can detect very low levels of contaminants and the realization that aquifers can be easily contaminated. Ground-water monitoring is required under several federal laws, including the Resource Conservation and Recovery Act (RCRA). RCRA requires ground-water monitoring for many facilities as part of their permit to operate. Under the Comprehensive Environmental Response Compensation and Liability Act of 1980 (Superfund), a hazardous waste generator is held liable for waste produced. This liability continues even when the material has been properly transferred to a transporter or to a treatment, storage or disposal site. In the event leachate is generated and moves to the ground water, he remains liable for these wastes even though the generator may have followed the letter and spirit of the law.

Monitoring organic compounds has been made possible by recent refinements in analytical chemistry in detecting organic compounds in the parts-per-billion range. Within the past few years, ground water in a number of industrialized areas of the country has been identified as contaminated. Even low levels of certain contaminants may result in health problems for persons utilizing water from contaminated aquifers, as some of the contaminants found may be carcinogenic or lack a minimum dosage under which no adverse health effect occurs. The U.S. EPA is devising a ground-water strategy to protect ground water from pollution sources.

The developer of a ground-water monitoring program for regulatory, health or environmental purposes has several options to consider. When properly devised, the monitoring program should be cost-effective and capable of detecting contaminants suspected of occurring and defining the extent of contaminant plumes.

Monitoring system factors outlined here are generalizations concerning the considerations that should be given to a monitoring program for either regulated or unregulated activities. Although some state and federal regulations may specify monitoring requirements, a technically sound monitoring program should be tailored to the site under study. For example, while RCRA requires that three wells be installed downgradient from monitored hazardous waste sites, additional wells may be necessary to properly identify complex ground-water conditions. Many site-specific factors must be considered in a monitoring program to adequately define site conditions. Due to the wide range of conditions encountered in nature, only a few recommendations can be provided in this article.

Figure 1 is a flow chart depicting a typical monitoring program. Of the activities that comprise design and implementation of a ground-water monitoring program, emphasis is placed on defining monitoring objectives, the constituents which should be considered for monitoring, criteria for selecting the analytical laboratory and other considerations on which a monitoring team must make decisions in order to collect representative data once well design, drilling methods and aspects of well development (Figure 1) have been determined. Scalf et al. (1981), Campbell and Lehr (1973), and Johnson Division (1966) provide through discussions on well drilling and related topics and should be referred to prior to developing the portions of the monitoring program identified here. Figure 1 should be viewed only as a general method for conducting a monitoring program. The order of activities may change due to objectives, site conditions, etc. In addition, research programs, political conditions and client needs can change or reorder the need for some activities.

Table 1 summarizes the cultural and field-related factors which can be used to determine which monitoring components should be incor-

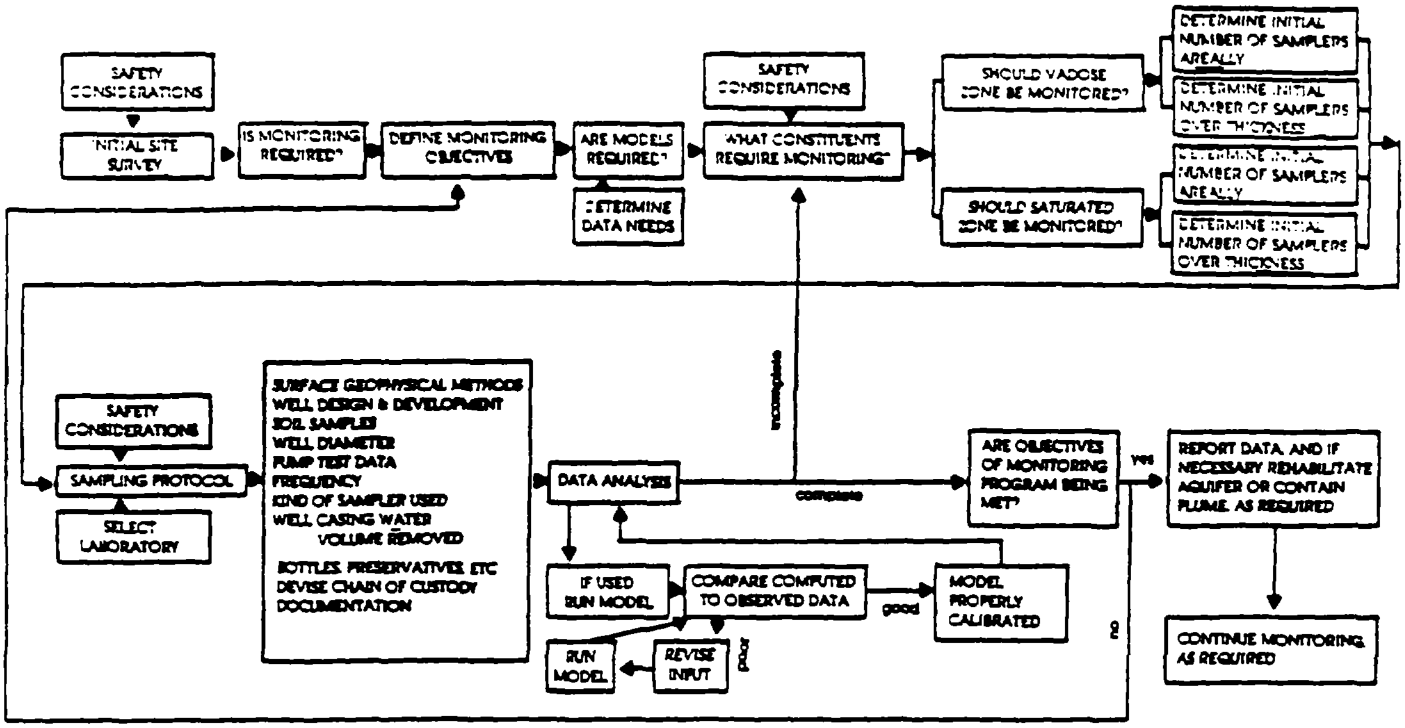


Figure 1. Flow chart for a typical monitoring program. The sequence of events and what is included will vary with the needs and objectives of the monitoring program

porated into the monitoring program. As the mix of factors changes from site to site, a "cookbook" approach cannot be used. For example, if the aquifer under analysis is used as a drinking water source and is to be monitored as part of a hazardous facility's monitoring program, more care may be necessary in determining sampling frequency to detect pollutant movement than if the aquifer were not used for drinking water. Along with frequency, the team must consider numerous other factors to arrive at the proper solution to the problem. Likewise, where legal proceedings are being undertaken against a party, chain of custody becomes very important. The second group of factors are in part site dependent or relate to particular parts of the protocol which should be taken into consideration during the design and implementation phases of a monitoring program. For example, sample volume is important in determining which constituents are to be analyzed when the vadose zone is to be monitored, as soil samples and pressure-vacuum lysimeters provide only small sample volumes. A number of these factors and monitoring components are discussed here and in Nacht (1983).

When Should Monitoring Be Undertaken?

Legislation on the federal and state levels is quickly defining when monitoring is required from a legal perspective. Major federal laws and regulations and state activity (as of 1980, 24 states or territories had some form of ground-water control [Wickersham and Canter 1980]) require or will require some form of monitoring or ground-water management.

Considerations not necessarily based on regulations which may dictate that monitoring should be conducted include:

- Location of industrial or commercial facilities handling large quantities of hazardous materials or wastes, even if these materials are not listed under RCRA. For example, polychlorinated biphenyls, which are listed under the Toxic Substances Control Act (TSCA).
- Facilities above heavily used or drinking water aquifers.
- Geologic materials that are highly fractured or have solution openings where attenuation or pollutants will be minimal and pollutant movement can be rapid and difficult to predict.
- Facilities located in communities concerned above the effects of industrial activity on the human population.
- Facilities that have experienced spills or other accidents, or those in which water pollution control devices have a history of failure resulting in a release of pollutants to surface water or ground water. This may be due to equipment malfunction, overloads, or large swings in process wastewater quality.
- Facilities which must comply with environmental or health regulations or which are undergoing legal proceedings involving pollution, health or similar problems, especially involving solid materials or water.
- Facilities using or managing compounds whose chemical or health effect properties may not be well known.
- Complaints by neighbors that the local surface water bodies or wells have degraded in quality or are producing foul odors.
- An observable increase in health problems in the area.

At this early stage of the investigation, an initial site survey will be necessary (Figure 1). Collection of readily available data on the extent of the problem, site visits and interviews with individuals involved directly with the problem are of great help and should begin at this time. If hazardous materials are involved, field investigators should determine as best as possible from the above sources what the nature and extent of the hazard(s) may be. Where necessary, field personnel should have safety equipment in use or readily available.

What Are the Objectives of the Monitoring Program?

Before a well is drilled and a water sample taken, the ground-water monitoring specialist should clearly determine what the monitoring program is to accomplish. Typical objectives might be, but are not limited to:

- Meeting regulatory requirements
- Determining site baseline ground-water quality and hydrologic conditions
- Determining why ground-water quality problems are occurring in the area
- Determining the effect of a facility discharging to the ground water, a special situation being as an early warning system to determine when pollution has begun or has changed in character or location
- Determining the effect of a particular activity on the environment
- Determining regional ground-water trends and background ground-water quality.

It is important to realize that objectives most likely will be closely related to environmental, political or socioeconomic conditions, history of the problem and hydrologic conditions at the site and that several of these objectives may be applicable to the solution of a defined problem. Objectives may also change with time due to environmental, regulatory, political or economic factors, a change in site ownership or in project management. Whenever objectives are chosen, they should be clearly defined and recorded in writing to document monitoring rationale for future management. This should also be done when the objectives or the program are changed. Documentation should include program objectives, parameters sampled, number of wells drilled, construction details etc., as decisions are made. This will ensure that the initial rationale is not lost and that the monitoring program is not conducted only for data collection which may have little relationship to objectives or future site conditions.

The definition of ground-water objectives is a major element that is undertaken during the initial phases of the program. To be successful, a monitoring team must keep the agreed-upon objectives in mind throughout the full course of the project, which may cover a period of many years. A critical review of objectives should be scheduled after data become available for analysis to determine if monitoring objectives are being met. A similar review should be conducted whenever objectives are changed. The purposes of the review are to keep the monitoring effort in line with objectives and to reduce costs. This review process should be conducted by the ground-water monitoring team, management and the client and may also include input from regulatory agencies. It is not unusual to refine the monitoring program once information on the site becomes available by adding or deleting wells and chemical parameters, or by changing the objectives of the monitoring program.

Table 1
Matrix of Ground-Water Monitoring Components to Factors to Consider in Designing a Monitoring Program

Included are some of the major factors affecting monitoring program design. The • indicates that a factor may have applicability in monitoring, although the degree of applicability may vary. Not all factors or components are shown due to the diversity in ground-water conditions nationwide.

Factor \ Monitoring Component	When to Monitor	Pollutants Monitored	Number of Wells Over Aquifer Thickness	Number of Wells Areally	Vadose Zone Monitoring	Sampling Protocol	Sampling Frequency	Well Diameter	Type of Sampler/Pump and Composition	Use of Models	Safety Considerations	Chain of Custody
Aquifer is a Drinking Water or Irrigation Source	▲	▲	▲	▲	▲		▲			▲		▲
Facility Handles Hazardous Materials	▲	▲	▲	▲	▲		▲			▲	▲	▲
Heavily Used Aquifer	▲	▲	▲	▲	▲		▲			▲		▲
Legal Proceedings	▲	▲	▲	▲	▲		▲			▲	▲	▲
Required by Regulations	▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲
Adequate Sample Volume					▲			▲	▲			
Attenuation of Pollutants		▲	▲	▲	▲		▲		▲	▲		
Background Concentrations		▲	▲	▲	▲		▲		▲			
Casing/Sampler Composition		▲			▲			▲	▲			
Complex Geology		▲	▲	▲	▲		▲			▲		
Depth Sample Taken in Well		▲	▲	▲				▲	▲			
Ground-Water Velocity		▲	▲	▲	▲		▲		▲			
Highly Variable Conditions		▲	▲	▲	▲		▲			▲		
Permeability		▲	▲	▲	▲		▲	▲	▲			
Plume Density		▲	▲	▲			▲			▲		
Rapid Water Level Changes	▲	▲	▲	▲	▲		▲		▲	▲		
Rapid Water Chemistry Changes	▲	▲	▲	▲	▲		▲		▲	▲		
Sample Representativeness		▲	▲	▲	▲		▲	▲	▲			▲
Vadose Zone Thickness			▲	▲	▲							

Which Constituents Require Monitoring?

Chemical constituents to be monitored are dependent on the type of materials handled by the facility, background water-quality considerations, health and environmental regulatory requirements, aquifer uses and site geology (Table 1). Facilities handling highly hazardous materials or materials that are a nuisance (conventional pollutants such as iron or total dissolved solids) should be considered for inclusion in the monitoring program. This requires knowledge of the facility's effluent. For a manufacturing plant, this data may be available from the NPDES or RCRA permit. For facilities lacking this data, it might be necessary to sample the effluent or runoff over time and analyze for suspected constituents based on process chemistry or compounds typical of those being released by the industry.

Another approach is to use the phased approach developed by EPA for analysis of complex energy facility waste streams (Dorsey et al. 1977; Harris et al. 1979). This approach may be useful for complex waste streams or when a thorough analysis of waste constituents is desired. It has three levels of effort. The first level (Level 1) provides preliminary analytical data that produces results with an accuracy and precision of ±2 or 3, which is sufficient to determine the presence or absence of a material or category of material. While not providing data on specific materials in all situations, a Level 1 analysis will provide data for initial priority ranking of what should be sampled. Level 2 identifies, quantifies and confirms specific components identified in Level 1 and provides statistically representative data as well as confirmation of Level 1 information. A Level 3 assessment uses sampling and analytical methods with precision and accuracy sufficient to permit quantification of specific pollutants identified under previous levels.

Background water-quality should also be determined. High levels of naturally occurring constituents may overshadow levels of contaminants resulting from human activity. For example, in many areas in the West, ground water has high levels of natural fluoride, lead or other trace metals which may be above drinking water standards or other use limitations. Knowledge of background concentrations will help to define changes taking place in the system.

While an enormous number of compounds can be suggested for monitoring, the following general groups of parameters, some of which overlap, will most likely make up most of the parameters sampled:

- Drinking water quality parameters
- Constituents required under a surface-water discharge permit (NPDES)
- Constituents for ground-water monitoring programs as required by RCRA
- Health effects constituents for unregulated drinking water contaminants (Suggested No Adverse Response Levels [SNARLS])
- Constituents identified by state and local requirements
- Constituents identified from a manufacturing plant's waste streams which may be toxic or cause a severe nuisance
- Constituents of local significance, such as naturally occurring radioactive isotopes in Florida's phosphate region
- Pollutants known to exist in the area, such as trichloroethylene (TCE) founding in a neighboring well
- Parameters which may help explain the ground-water chemistry, such as dissolved gases, pH etc.

The number of parameters in a sampling program may vary over time. Therefore, the large number of parameters initially analyzed in many programs may be reduced once site conditions are fully understood. When properly conducted, the high initial sampling costs for a long-term program can frequently be reduced to an economical program which provides the most information for the funds available.

Which Analytical Laboratory?

The question refers not to finding a laboratory, but to determining which ones will produce results that are accurate and precise and can meet project objectives. Excluding cost and locality, a few questions to ask when looking for a laboratory are:

- Does the laboratory have a quality control/quality assurance program? These programs are designed to minimize systematic and random variables in the measurement and data collection process, provide prompt detection and correction of conditions leading to production of poor-quality data, collect and supply information to describe data quality and evaluate overall adequacy of the data gathering process as it affects data quality. Two good information sources to begin with are The Handbook for Analytical Quality Control for Water and Wastewater Laboratories (U.S. EPA 1979) and NEIC Policies and Procedures Manual (U.S. EPA 1978).
- Is the quality control/quality assurance program in writing? This document should be up-to-date and available to all analysts for reference. The program should also provide a feedback mechanism to inform the analyst of problems.
- Are unknown, blanks and spiked samples frequently used? These tools are helpful in early detection of analytical problems.
- Is the lab clean when you visit it? Equipment that is covered at the end of use and kept clean by the analyst generally has a better history of operation than unkept equipment. Clean labs and equipment promote a good environment to conduct analysis and also reduce sample contamination.
- Does the lab participate in round robin or other testing programs? This is a good tool to determine how a lab compares to other labs under similar conditions. For instance, the state of Ohio requires that some self-monitoring data obtained by regulated entities be analyzed at certified laboratories.
- Is the lab certified by the state EPA (or equivalent regulatory authority) for drinking water or other regulated activities? Certification provides some indication that the lab is capable of properly analyzing samples.
- Are analysts certified by state agencies and also provided ongoing training by the lab to refresh and expand their expertise? This provides some indication that management and analysts are concerned about discharging their duties in a professional manner.
- What are the levels of detection for the various parameters analyzed by the laboratory? Some labs may have unnecessarily high detection limits for the parameters of interest. Under these conditions, a laboratory may report that the constituent was not detected and provide incorrect information for decision making.
- Is turnaround rapid? Will you be able to get results in a reasonable time? To manage this problem, large labs are now using data processing systems that interface with major analytical equipment, reducing errors and turnaround time.
- Are sample splitting and preparation areas removed from analytical areas to reduce contamination? Also, are areas and equipment dedicated for trace analysis of materials? These problems are becoming major concern in the analysis trace levels of materials to reduc contamination from dust and other minor contaminants. As equipment becomes more sensitive and the number of samples increases, clean

rooms are also becoming the norm.

• Can confidentiality be provided regarding laboratory results, especially if a computer is used to store data and write laboratory reports? Access to the computer by laboratory personnel should be through a unique code that ensures that data will be kept confidential.

These questions should provide an indication of what to look for in an analytical laboratory. Smaller labs may not be capable of providing all of the above, but may still produce very good results. If no other criteria are used during your visit to the lab, the observation of pride in the analyst's work and desire to do a good job are signs that the lab's management and personnel will most likely meet your needs.

Should One Well or Clusters Be Used?

Location of a plume of contaminated water can be a hit-or-miss proposition, due to the density of the plume with respect to ground water, variations in permeability, heterogeneity of aquifer materials and other aquifer conditions. While odor may be used to detect some compounds, this simple test to detect pollutants may not be helpful when low levels of pollutants are involved, which may be further diluted in concentration if the well is open throughout the full aquifer thickness. Detection of trace qualities of compounds in the parts-per-billion range can be subject to sample contamination and sample noise, indicating that aquifer contamination may or may not exist. Under these conditions, consideration should be given to installing clusters of wells at various depths to sample smaller vertical segments of the aquifer. Fenn et al. (1977) suggested the use of three cluster arrangements when contamination from a landfill is suspected:

• At the top and bottom of the aquifer

• Adding a third well to the above in the middle of the aquifer

• At preselected intervals (such as every 3m (10 ft)).

This technique can also be used if several aquifers underlie the site. If hazardous materials are suspected of occurring at the site, care should be taken not to spread contamination by installing clusters of wells (or piezometers) in a single borehole that will interconnect the aquifers. If clusters are used in this situation, all wells in a cluster should be dedicated to a specific aquifer.

Several factors which may affect the number of wells necessary include pollutant attenuation (if known), background concentrations for the constituents under study and other hydrologic parameters which will influence contaminant movement. A number of these factors are identified in Table 1.

Under certain conditions where the aquifer is thin (i.e., on the order of several meters), the geology simple, the density of the plume about equal to water and the velocities low, one well open over the entire thickness may be used to detect contaminants.

Although installation of wells is expensive, the analysis of trace organic compounds (for example the 129 priority pollutants—mostly organics), can easily cost $1,000 or more per sample. By specifying clusters, it may be possible to reduce or at least not greatly increase sampling and analytical costs while allowing for a more representative sampling over the aquifer's thickness and increasing chances for plume detection. Still, contaminants may not be detected.

Number of Wells Necessary to Determine Areal Extent of Pollution

Considerations are similar to those in the previous section. As a plume cannot be readily observed without wells or other devices, some exploratory wells may need to be installed to provide preliminary information prior to a commitment for a full monitoring program. In many instances, conductivity, surface resistivity or temperature surveys can be used to define a plume, as plumes are usually more conductive or may be warmer than native ground water. When pollution is significant, all three methods can usually produce an obvious demarcation. Knowledge of site soils and geology, specifically composition and variability, relative permeability and geologic structures, are needed to determine general plume geometry.

As is the situation with most aspects of ground-water monitoring, professional experience is required to determine the appropriate number of sampling points. An absolute minimum of three wells or piezometers are required to determine the slope of the water table or piezometric surface, which can be helpful in determining monitoring well configuration. Most situations will require many more wells or piezometers to define [illegible] geologic site conditions or the three-dimensional form of a plume. However, the expense of this large number of wells and piezometers is often prohibitive for owners of small landfills and other facilities, making site selection of the few wells and piezometers used even more important.

When Should Models Be Used to Predict Aquifer Hydraulics or Plume Movement?

There is a definite place for use of sophisticated computer models in a ground-water monitoring study. When used properly, models can assist in the analysis of data (Figure 1) and provide management with information or decision making. Models are useful where geology is very complex or where numerous waste sources or complex pumping patterns exist (Table 1). Another situation in which models may be useful is in the evaluation of aquifers in which water withdrawals are significant and information on the effect of additional pumping or input of pollutants to the aquifer may be critical, and in which the prediction of ground-water conditions at some point in the future is desired.

For example, location of a waste disposal site in fractured or in highly heterogeneous glaciated terrains poses problems to the monitoring team, which must predict the direction of travel and areal extent of a leachate plume. In fractured-rock terrain, lack of information on the location of fractures complicates prediction of the flow path of contaminated ground water. Models capable of handling this situation are not yet able to adequately solve this problem. However, there are models available which are capable of providing some insight into the transport of solutes in the subsurface. These can be used, with some modifications, to predict flow in fractured media.

Models applied in areas of complex geology, such as in highly heterogeneous glacial terrain, are also useful. Here, materials and hydrologic characteristics can also be expected to vary rapidly both laterally and vertically. As in fractured-rock terrain, the ground-water specialist must identify the areal and vertical geologic and hydrologic changes and understand the processes which created and are presently affecting site geology prior to modeling or monitoring. Once this and applicable information is available, modeling can proceed.

In situations where aquifers are mined for water or heavily used, any additional withdrawal (or addition of leachate) can be modeled to determine its effects on the system. Models can be utilized to predict the effects of flow in an aquifer, complex pumping patterns, boundary conditions and other factors. Several other points on modeling are:

- Models need not be used unless a definite advantage results from their use over standard field and analytical procedures.
- If results are to be considered valid, all models will require significant input data to run and verify for the site under analysis. Models cannot be used in place of initial data collection and monitoring; rather they are an extension of monitoring.
- The field geologist or hydrologist and the modeler should become more familiar with the problems and objectives and their respective duties, to better complement one another.
- Only the skilled geologist or hydrologist, modeler and decision maker can decide what is correct for the problem under analysis. This implies that model outputs may be used in several ways to provide different results depending on the socioeconomic, political and other technical conditions as viewed by the technician and decision maker. Stating that the model provided the solution to a problem is only partially correct, as it furnishes the basis for a decision and management and operations activities.

Should the Vadose Zone Be Monitored?

Until recently, few ground-water specialists monitored the vadose zone, believing that monitoring of the saturated zone was sufficient for protection of ground-water resources. Unfortunately, aquifer rehabilitation methods in the saturated zone are expensive and may not be entirely suitable once large-scale contamination has occurred.

The objectives of a vadose zone monitoring system are to reduce saturated zone monitoring costs and to allow for the early recognition of problems while pollution is in the vadose zone. Under these conditions, ground-water rehabilitation may be less costly and the source of the problem may be easily corrected. Vacuum lysimeters can be used to collect water samples from beneath landfills, ponds or other discharging facilities where pollution can be expected to move from the vadose zone to the saturated zone. Monitoring is generally suitable where the vadose zone is thick, perhaps greater than 10m (33 ft). It is particularly applicable in arid regions where the vadose zone can be more than 100m (330 ft) thick. Use of vacuum lysimeters to sample the vadose zone will reduce but not eliminate the need for saturated zone monitoring.

Present technology has numerous problems which make routine use of lysimeters difficult. Problems include the small water sample volume available, the potential for clogging and the possibility of equipment failure. Also because only a small volume of soil surrounding the lysimeter is sampled (point sample), vacuum lysimeters must be installed through the waste or around the perimeter of the waste. This may provide a path through a damaged lysimeter or through the annular space for wastes to migrate and further pollute the vadose zone and/or pollution movement from beneath a facility.

Determining the number of sampling points required areally and with depth poses problems similar to those mentioned earlier for saturated zone monitoring. Factors to consider for vadose zone monitoring include the thickness and permeability of the vadose zone, the attenuation capacity of soils and geologic materials and the degree of hazard the leachate being sampled poses. Salk and Decicco (1978) developed recommendations based on vadose zone thickness which may be useful for initial determination of the number of sampling points required. Under conditions where permeability is high, attenuation is minimal and hazardous materials are involved, it should be prudent to use well clusters and increase the density of vacuum lysimeters installed surrounding and beneath the site.

Because of the many problems involved with vacuum lysimeters, site investigators may find soil samples helpful. These samples can provide information on contaminants sorbed onto soil particles that either are not released back to the water or released only when chemical or physical conditions change. In addition, other devices can be used to trace (but not sample) water flux through the vadose zone such as soil moisture blocks, pschrometers and tensiometers.

When Should Safety Precautions Be Taken?

All drillers and many hydrogeologists are familiar with the Occupational Safety and Health Administration (OSHA) and the rules promulgated to promote on-the-job safety. In working with hazardous waste, additional precautions may be required to protect the driller and the hydrogeologist. Safety devices may be required when hazardous materials are suspected. Precautions take the form of protective devices, clothing and hazardous materials management. These include breathing devices, self-contained suites, gloves, decontamination of drill rig, sampler and surrounding area and safe handling of samples including the preservation of unstable materials to reduce generation of heat or toxic gases and packaging following EPA and DOT rules, if shipped over public rights of way.

As the monitoring team may not know what to expect at a site, a review of production, waste analysis or disposal data and available chemical sampling and analysis data of water and soils will provide an idea of the situation's hazardousness. Using safety precautions it might be advantageous for monitoring personnel to secure a sample from leachate springs, contaminated wells or through installation of shallow well points. By analyzing for suspected hazardous materials before bringing in additional personnel and equipment, the associated high medical and decontamination costs might be reduced. Most importantly, costs to human health will be averted.

Concern over personnel safety should continue beyond the initial phases of the monitoring program. As identified in Figure 1, it is important that proper safety precautions are taken if hazardous materials are suspected or are found at the site. These precautions should be taken throughout the life of the monitoring program from the initial site visit, sampling phase and the handling of samples in the laboratory.

As this is a new area of concern, the hydrogeologist should contact a local industrial hygienist or public health specialist when a problem is suspected. A medical university or hospital can also be contacted for assistance. If a client has a staff industrial hygienist. It is critical that a close working relationship be established prior to site work. The objective of this is to reduce human contamination from drilling and sampling operations through proper protective gear, hygiene and appropriate health screening tests.

Conclusions

This article should not be considered as the final statement on what is required for a monitoring program. It is an initial compilation of a number of the more significant generic factors which should be considered in the design and operation of a ground-water quality monitoring system. The great diversity of conditions nationwide may never allow for a comprehensive listing of factors. Each site must require a separate evaluation of the factors briefly discussed. Monitoring system decisions by the hydrogeologist on a particular site may vary dramatically from those outlined here. Additional effort is required in developing computer models that can more accurately predict ground-water flow and solute transport in complex terrain, health and safety education, determining the effect of pollutants on the ground-water system, contamination of unpolluted aquifers during drilling and other factors.

References

Campbell, M. and J. Lehr. 1973. Water well technology. McGraw-Hill. New York.

Dorsey, J., L. Johnson, R. Statnick and C. Lockmuller. 1977. Environmental assessment sampling and analysis: phased approach and techniques for Level 1. U.S. EPA. EPA-600/2-77-115. Research Triangle Park, North Carolina.

Fenn, D., E. Cocozza, J. Isbiter, O. Braids, B. Yare and P. Roux. 1977. Procedures manual for ground-water monitoring at solid waste disposal facilities. U.S. EPA. EPA/530/SW-611. Cincinnati, Ohio.

Harris, J., M. Hayes, P. Levins and D. Lindsay. 1973. EPA/IERL-RTP procedures manual for Level 2 sampling and analysis of organic materials. U.S. EPA. EPA-600/7-79-033. Research Triangle Park, North Carolina.

Johnson Division. 1966. Ground water and wells. St. Paul, Minnesota.

Nacht, S. 1983. Ground-water monitoring sampling protocol considerations. In press.

Salk, M. and S. DeCicco, editors. 1978. Environmental monitoring handbook for coal conversion facilities. Oak Ridge National Laboratory. ORNL-5319, special. Oak Ridge, Tennessee.

Scalf, M., J. McNabb, W. Dunlap, R. Cosby and J. Fryberger. 1981. Manual of ground-water sampling procedures. U.S. EPA. Robert Kerr Environmental Research Laboratory. Ada, Oklahoma.

U.S. EPA. 1978. NEIC policies and procedures manual. National Enforcement Investigations Center. EPA-330/9-78-001. Denver, Colorado.

U.S. EPA. 1979. Handbook for analytical quality control in water and wastewater laboratories. EPA-600/4-79-019. Cincinnati, Ohio.

Wickersham, G. and L. Canter. 1980. Summary of state ground-water laws. Report No. NCGWR 80-19. National Center for Ground Water Research. Ada, Oklahoma.

Biographical Sketch

Steve Nacht is a certified professional geologist with Lockheed Engineering and Management Services Co. He earned his M.S. in geology from Kent State University in Kent, Ohio in 1973 and an M.S. in environmental sciences in 1979 from Cleveland State University. Nacht developed ground-water monitoring guidelines from commerical scale coal gasification, liquefaction and oil shale facilities for the U.S. EPA, Las Vegas Laboratories and has been involved in assisting industry with hazardous waste management and ground-water monitoring system design and implementation to comply with the Resource Conservation and Recovery Act.

APPENDIX 16-C

GUIDELINES FOR SELECTION OF DRILLING TECHNIQUE(S)

DRILLING METHODS

Selection of the drilling method best suited for a particular job is based on the following factors in order of importance:

- (1) Hydrogeologic Environment
  - (a) Type(s) of formation(s)
  - (b) Depth of drilling
  - (c) Depth of desired screen setting below water table
- (2) Types of pollutants expected
- (3) Location of drilling site - dry land, or inside a lagoon
- (4) Design of monitoring well desired
- (5) Availability of drilling equipment

The principles of operation, advantages and disadvantages of the more common types of drilling techniques suitable for constructing ground-water monitoring wells are discussed as follows.

Mud Rotary

Principles of Operation: A drilling fluid is pumped down the inside of the drill pipe, and then returns to the surface through the annulus between the drill pipe and the borehole wall (Figure 8). This fluid cools the drill bit, carries the cuttings to the surface, prevents excessive fluid loss into the formation, and prevents the formation from caving. The rotating drill pipe turns the bit which cuts the formation allowing the cuttings to be flushed out.

The drilling fluid may be clear water, water mixed with bentonite or water mixed with a biodegradable organic "mud".

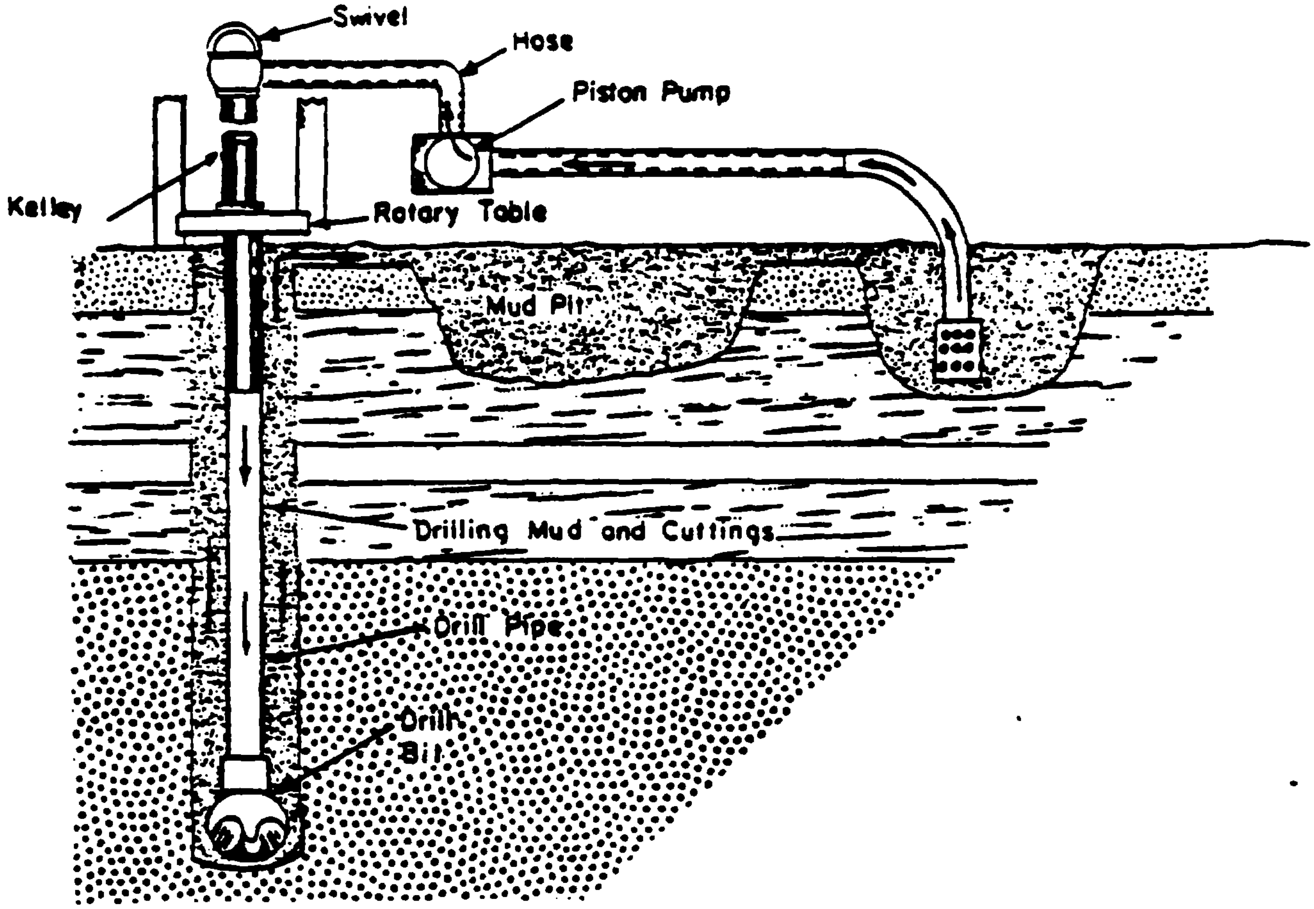
Mud rotary rigs are the most common rig available. Other types of drilling rigs are, however, better suited for certain geologic environments and for many water-quality sampling programs.

Advantages:

- (1) Available throughout the U.S.
- (2) Capable of drilling all formations, hard or soft.
- (3) Capable of drilling to any depth desired for monitoring.
- (4) Casing not required during drilling.
- (5) Formation logging (sampling) is fairly reliable in most formations.
- (6) Relatively inexpensive.

Disadvantages:

- (1) Drilling fluid mixes with formation fluid and is often difficult to completely remove.
- (2) Bentonite (if used to minimize fluid loss) will adsorb metals and may interfere with some other parameters, thereby making this drilling method (at least the use of bentonite drilling mud) undesirable where metals are being sampled.
- (3) Organic/biodegradable additives mixed with the water to minimize fluid loss will interfere with bacterial analyses and organic-related parameters.
- (4) No information on the position of the water table, and only limited information on water-producing zones is directly available during drilling. Electric logging of rotary drilled wells can substantially add to the accuracy of the driller's log and to water-related information.
- (5) Circulates contaminants.



The drilling fluid (or water) is pumped through the swivel and down through the kelley which is turned by the rotary table. The mud then flows down through the drill pipe, out through the bit and back up the hole carrying cuttings which settle out of the mud in the first section(s) of the mud pit.

Figure 8. Mud Rotary Drilling

Air Rotary

Principles of Operation: An air-rotary rig operates in the same manner as a mud-rotary rig except that air is circulated down the drill pipe and returns (bringing the cuttings) up the annulus. Some rotary rigs are equipped to operate either with mud or air. Air rotary rigs are available throughout much of the U.S. and are well suited for many ground-water quality programs.

Advantages:

(1) No drilling fluid is used, therefore, contamination or dilution of the formation water is not a factor.
(2) Air-rotary rigs operate best in hard rock formations.
(3) Formation water is blown out of the hole along with the cuttings, therefore, it is possible to readily determine when the first water-bearing zone is encountered.
(4) Collection and field analysis (after filtering) of water blown from the hole can provide enough information regarding changes in water quality for some parameters such as chlorides for which only large changes in concentration are significant.
(5) Formation sampling ranges from excellent in hard, dry formations to nothing when circulation is lost as in formations such as some limestones or other formations with cavities.
(6) Air rotary rigs are common and readily available throughout most of the U.S.

Disadvantages:

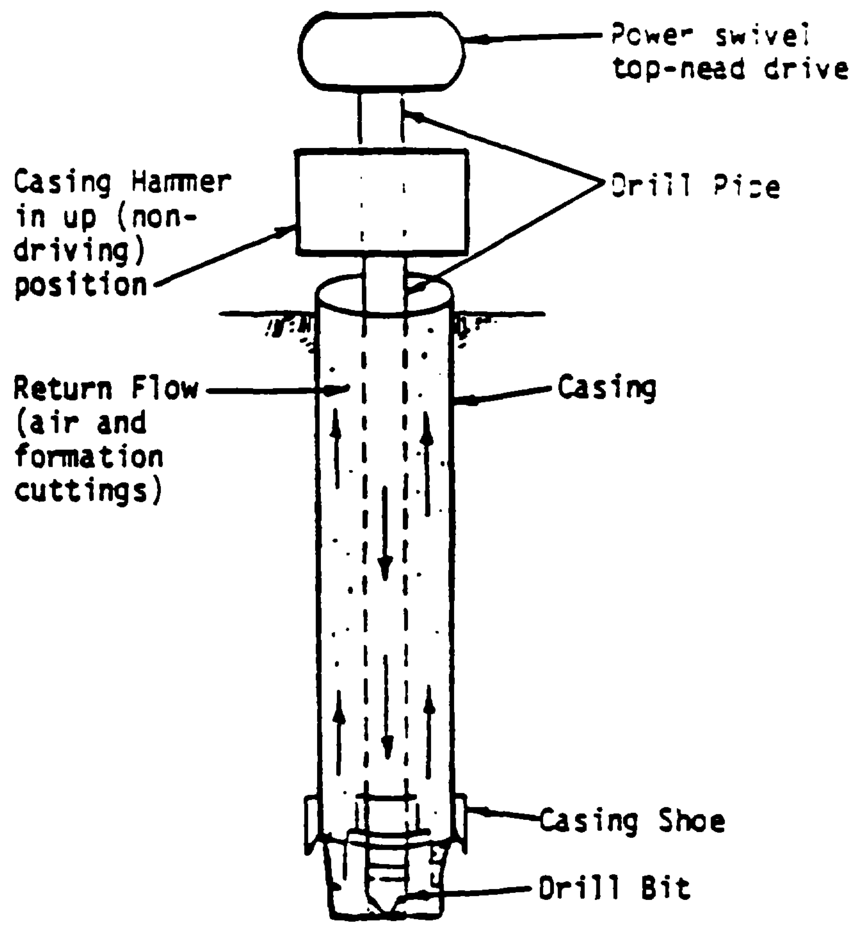
(1) Casing is required to keep the hole open when drilling in soft, caving formations below the water table. This is often a major disadvantage.
(2) When more than one water-bearing zone is encountered and where the hydrostatic pressures are different, then flow between the zones will occur between the time when the drilling is done and the hole can be properly cased and one zone grouted off.

Air Drilling with Casing Hammer

Principles of Operation: A top-head drive rotary rig can be modified to accept a casing hammer. The method of drilling is the same as with air rotary except that when caving formations are encountered the casing hammer drives the casing down to prevent the hole from caving (Figure 9). The casing can be driven without withdrawing the drill pipe. This drilling method is generally excellent for constructing monitoring wells in unconsolidated formations.

Advantages:

(1) Same advantages as with standard air rotary drilling except that soft, caving formations can be drilled.
(2) The use of casing minimizes flow into the hole from upper water-bearing layers, therefore multiple layers can be penetrated and sampled for rough field determinations of some water quality parameters.



An air drill with casing hammer operates like an air rotary drill except that in caving formations the casing can be driven to hold the hole open. The casing hammer is slipped down over the drill pipe and attached to the top of the casing and by a hammering motion, drives the casing. Usually the drill bit has drilled below the casing somewhat, but the casing shoe cuts a larger hole than the drill bit and therefore has to be driven.

Figure 9. Air Drill with Casing Hammer

Disadvantages:

(1) Air-rotary rigs with casing hammers are not in common use throughout the United States and may be difficult to locate in some areas.

(2) The cost per hour or per foot is substantially higher than other drilling methods.

(3) It is difficult to pull back the casing if it has been driven very deep - say deeper than 50 feet in many formations.

Cable Tool

Principles of Operation: A cable tool rig uses a heavy, solid-steel, chisel-type drill bit suspended on a steel cable, which when raised and dropped chisels or pounds a hole through the soils and rock (Figure 10). When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. After sufficient water is entering the borehole to replace the water removed by bailing then no further water need be added.

When soft caving formations are encountered, it is necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole. The shoe in fact cuts a slightly largerhole than the drill bit. This tight-fitting drive shoe should not, however, be relied upon to form a seal from overlying water-bearing zones in water quality investigations.

Advantages:

(1) Formation samples can be excellent with a skilled driller using a sand-pump bailer.

(2) Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.

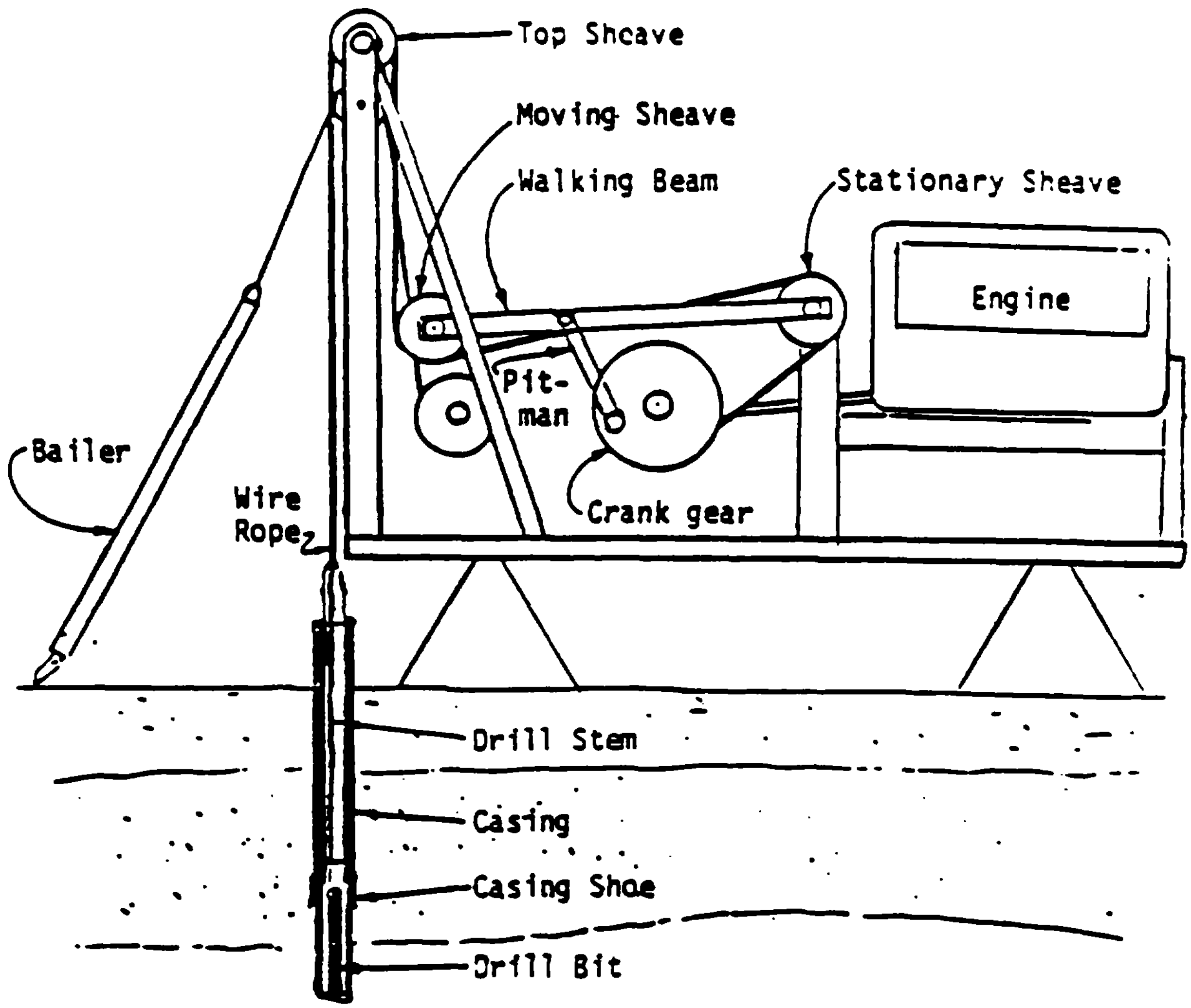
(3) The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, large gravel type formations or formations with large cavities above the water table (such as limestones).

Disadvantages:

(1) Drilling is slow compared with rotary rigs.

(2) The necessity of driving the casing along with drilling in unconsolidated formations requires that the casing be pulled back to expose selected water-bearing zones. This process complicates the well completion process and often increases costs.

(3) The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in large costs compared with rotary drilling and plastic casing.



The cable tool (sometimes called churn drill or percussion drill) operates as follows: Rotation of the crank gear causes the pitman to raise and lower the walking beam which is anchored at the stationary sheave end. The moving sheave end of the walking beam moves up and down causing the wire rope passing over the top sheave to alternately raise and lower the heavy drill stem and bit which drills the hole. The bailer is used to remove cuttings, and the casing is driven into the hole to prevent caving in soft formations.

Figure 10. Cable Tool Drilling

(4) It is difficult to place a positive grout seal above the drive shoe of the casing. Therefore, either the drive casing must be totally removed and the seal placed around the outside of an inner casing, or a seal must be placed above the screen but below the drive shoe. Either procedure adds to the cost and time of completion.
(5) Cable-tool rigs have largely been replaced by rotary rigs in some parts of the U.S.; hence availability may be difficult.

Reverse Circulation

Principles of Operation: The common reverse-circulation rig is a water or mud rotary rig with large diameter drill pipe and which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water-quality sampling wells.

Special Reverse Circulation

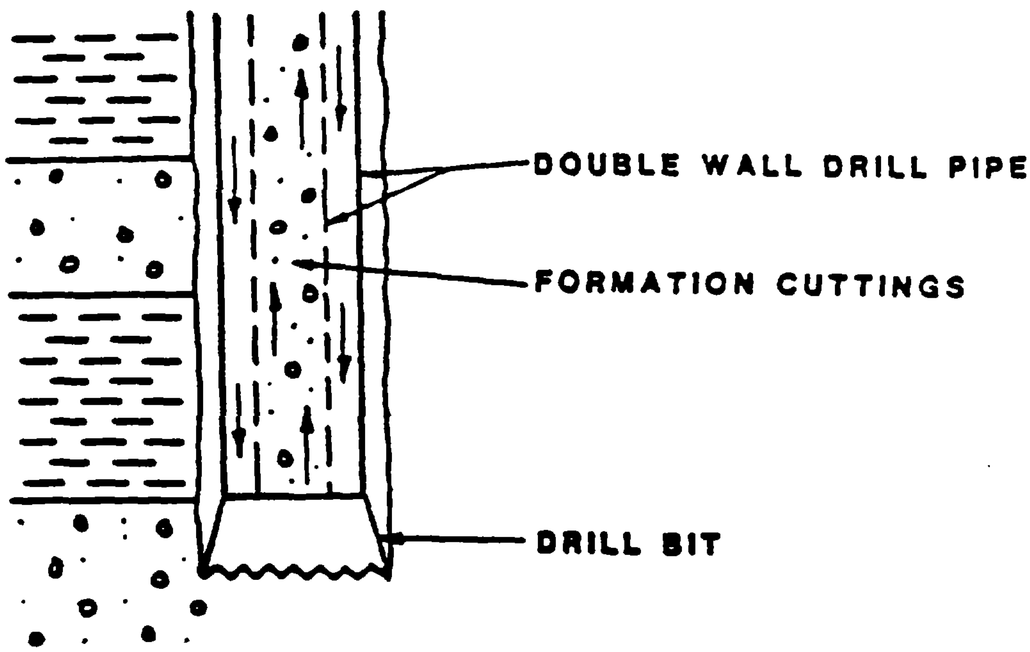
Principles of Operation: A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe (Figure 11).

Advantages:
(1) The formation water is not contaminated by the drilling water.
(2) Excellent formation samples can be obtained.
(3) When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
(4) Caving of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air rotary rig.

Disadvantages:
(1) Double-wall, reverse-circulation rigs are very rare and expensive to operate.
(2) Placing cement grout around the outside of the casing above the screen of the permanent well often is difficult - especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

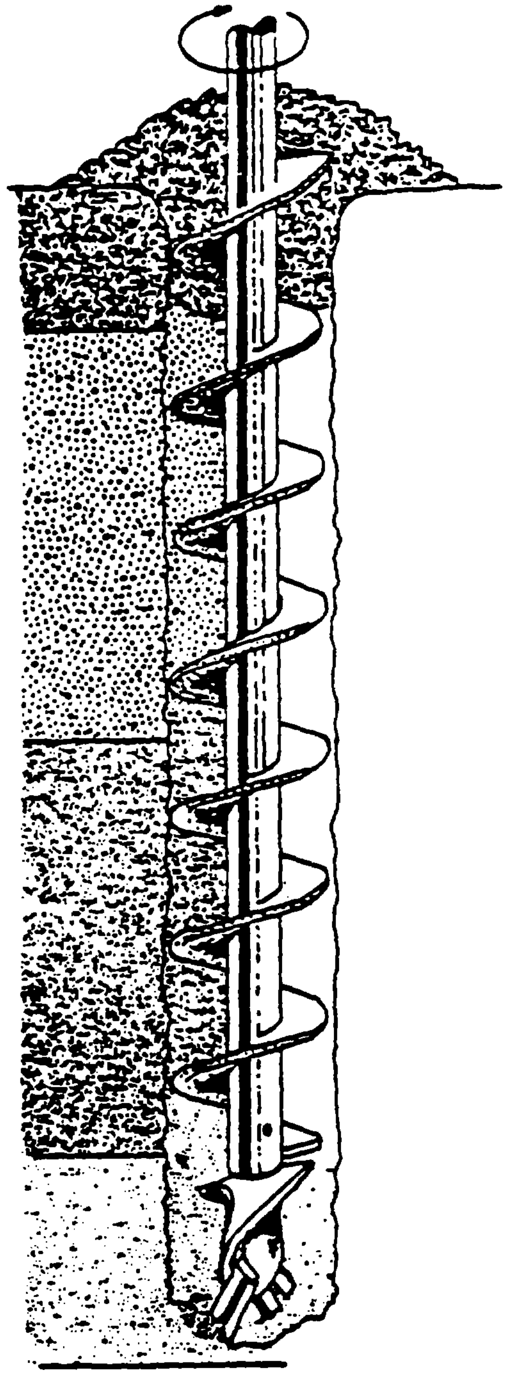
Solid-Stem Continuous-Flight Auger

Principles of Operation: Drilling is accomplished by rotating the solid stem, continuous-flight augers into the soils. As the augers are "screwed" into the soils, the cuttings are brought to the surface on the rotating flights (Figure 12). Auger bits are essentially of two types: fish tail or drag bits for use in unconsolidated materials, and claw or finger bits for



Air or drilling fluid is pumped down the annulus of the double-wall drill pipe. Formation cuttings are brought up the inside of the inner pipe along with the return air or fluid.

Figure 11. Special Reverse Circulation



The continuous-flight auger bores into the soil and rotates the cuttings upward along the flights. The uppermost cuttings are discharged at the surface to make room for the space of the auger as it penetrates additional soils.

Figure 12. Continuous Flight Auger Drilling

use in more compacted, lithified or cemented soils. Once the desired depth is reached, the augers are allowed to rotate to clean out the borehole. The augers are then removed from the borehole and well screen and casing installed. This method is best applied when installing monitor wells in shallow unconsolidated formations.

Advantages:

(1) The auger drilling rigs are generally mobile, fast and inexpensive to operate in unconsolidated formations.
(2) No drilling fluid is used, therefore contamination problems are minimized.

Disadvantages:

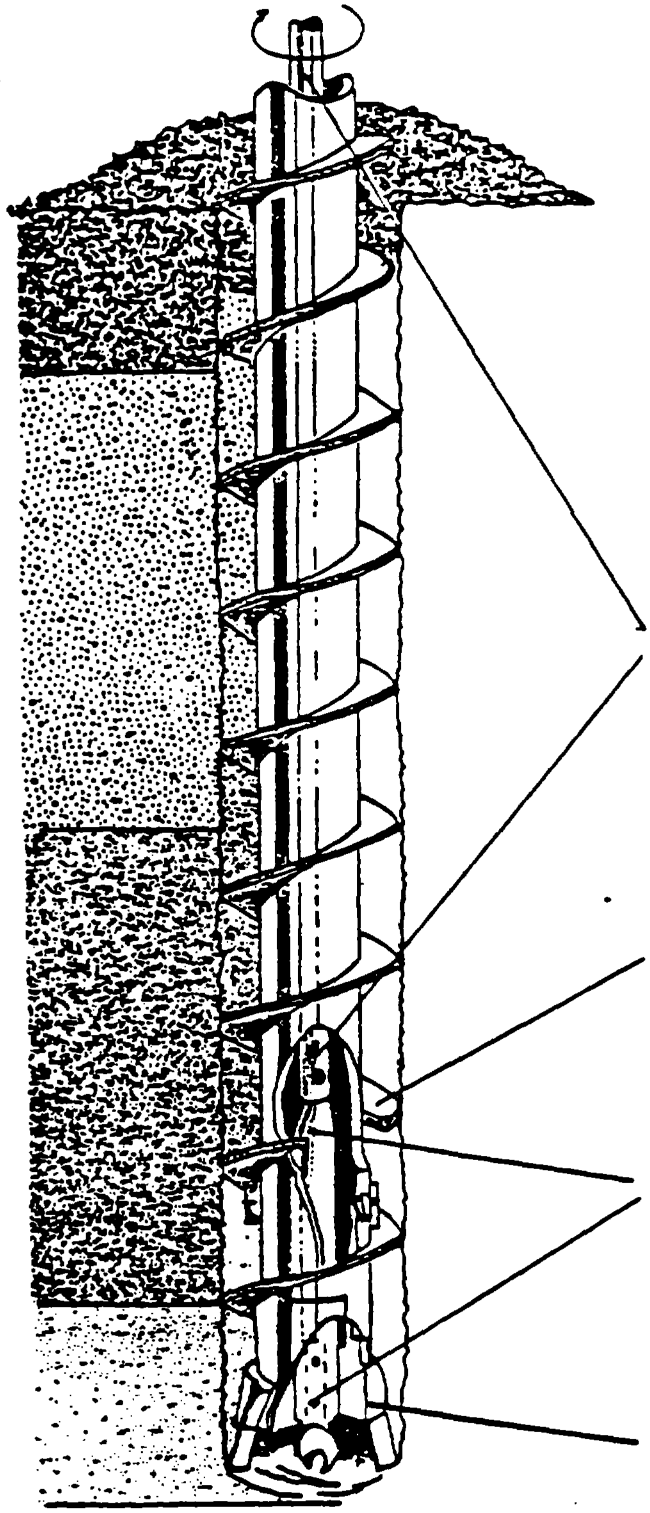
(1) Cannot be used in hard rock.
(2) Depth limitation varies with equipment and type of soils but approximately 150 feet is maximum.
(3) Once the augers have been withdrawn, the degree to which the borehole will remain open is dependent upon the degree of soil consolidation and saturation. Most boreholes will collapse below the water table.
(4) Formation samples may not be completely accurate.
(5) Depth to the water table may be difficult to determine accurately in deep borings.

Hollow-Stem, Continuous-Flight Auger

Principles of Operation: This method differs from the solid stem augers in that the stem is hollow. Upon reaching the desired depth, a small diameter casing and screen can be set inside the hollow stem (Figure 13). The augers are then pulled-out as the casing is held in place.

Advantages:

(1) The auger drilling rigs are generally mobile, fast, and inexpensive to operate in unconsolidated formations.
(2) No drilling fluid is used, therefore contamination problems are minimized.
(3) The problem of the hole caving in saturated, unconsolidated material, as when the solid-stem, continuous-flight auger is pulled out of the hole, is overcome by placing the casing and screen down inside the hollow stem before the augers are removed.
(4) Natural gamma-ray logging can be done inside the hollow stem which permits defining the nature and thickness of the formations penetrated.
(5) A grout seal can be placed around the permanent casing by attaching a cement basket above the screen before setting the assembly inside the hollow stem. Grout is placed in the annulus between the casing and hollow stem and the augers are pulled out. Grout is continuously injected or placed until all augers are removed.



The hollow-stem, continuous-flight auger bores into soft soils carrying the cuttings upward along the flights. When the desired depth is reached, the plug is removed from the bit and withdrawn from inside the hollow stem. A well point (1½-in. or 2-in.) can then be inserted to the bottom of the hollow stem and the auger pulled out leaving the small-diameter monitoring well in place.

Figure 13. Hollow Stem Auger Drilling

Disadvantages:
(1) Cannot be used in hard rock.
(2) Depth limitation varies with equipment and type of soils but approximately 150 feet is practical.
(3) Formation samples may not be completely accurate.
(4) Depth to the water table may be difficult to determine accurately in deep borings.

Keck Screened, Hollow Stem, Continuous Flight Auger (14)

Principles of Operation: This method operates the same as the hollow-stem augers except that the lead section incorporates a well screen (Figure 14).

Advantages:
(1) The auger drilling rigs are generally mobile, fast and inexpensive to operate in unconsolidated formations.
(2) No drilling fluid is used, therefore contamination problems are minimized.
(3) The problem of the hole caving in saturated, unconsolidated material, as when the solid-stem, continuous-flight auger is pulled out of the hole, is overcome by placing the casing and screen down inside the hollow stem before the augers are removed.
(4) Natural gamma-ray logging can be done inside the hollow stem which permits defining the nature and thickness of the formations penetrated.
(5) A grout seal can be placed around the permanent casing by attaching a cement basket above the screen before setting the assembly inside the hollow stem. Grout is placed in the annulus between the casing and hollow stem and the augers are pulled out. Grout is continuously injected or placed until all augers are removed.
(6) Depth to water table can be accurately determined.
(7) Water samples can be collected at any desired depth below the water table during the drilling operation without removing the augers or setting a screen and casing.

Disadvantages:
(1) Cannot be used in hard rock.
(2) Depth limitation varies with equipment and type of soils but approximately 150 feet is practical.
(3) Formation samples may not be completely accurate.

Bucket Auger

Principles of Operation: The bucket auger consists of a relatively large (8-inch minimum diameter by 2 feet long) bucket with a cutting edge on the bottom which is slowly rotated by a square, telescoping kelley or drill stem. When the bucket fills with cuttings, it is brought to the surface and emptied. This method is good for constructing shallow wells just into the water table in unconsolidated formations.

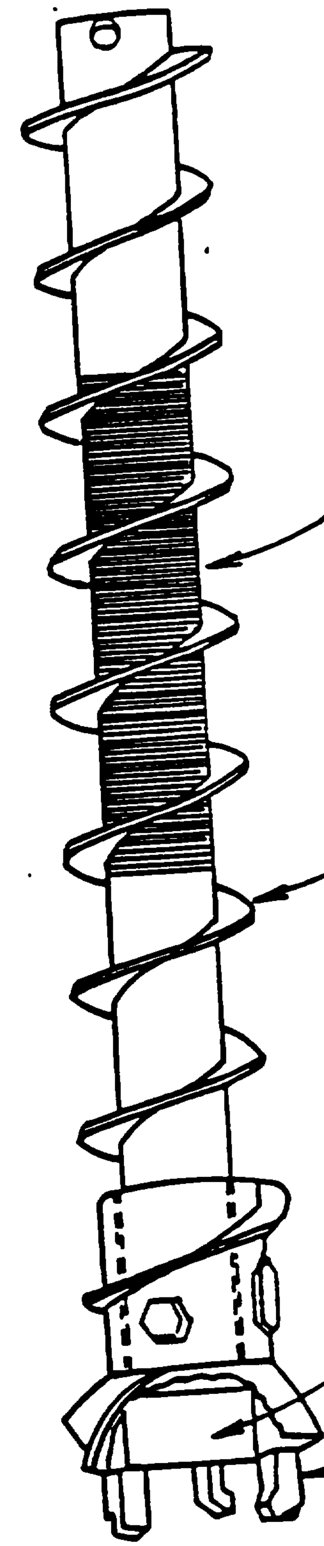


Figure 14. Keck Screened, Hollow Stem, Continuous Flight Auger

Advantages:

(1) No drilling water is required when either drilling above the saturated zone, or below the saturated zone in non-caving formations.

(2) After the hole has been drilled, the setting of casing with screen and grouting the outside of the casing to form a seal is relatively easy.

(3) Formation sampling is excellent.

Disadvantages:

(1) The hole diameter is large, hence the annular space is large when small diameter casing is used. This requires careful grouting and backfilling to insure water sample integrity.

(2) In caving formations below the water table it is necessary to continuously add water to prevent caving.

(3) Use of the bucket auger is restricted to soft formations and depths less than about 50 feet.

(4) These rigs are not widely available.

<u>Jetting</u>

Principles of Operation: Jetting consists of pumping water or drilling mud down through a small diameter (1½ to 2-inch) standard pipe. The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

This method is acceptable in very soft formations, for shallow sampling, and when introduction of drilling water to the formation is not a consideration.

Advantages:

(1) Jetting is fast and very inexpensive.

(2) Because of the small amount of equipment required, jetting can be accomplished in locations where it would be very difficult to get a normal drilling rig. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.

(3) Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Chapter 8 — Bored Wells

By B. P. Ward

A rose may be a rose may be a rose, but augering is boring is rotary bucket drilling, a process for developing ground water sources in wide use in the southeastern U.S. Under any and all these terms, it is a method for providing relatively large diameter and relatively shallow wells. The author is B. P. Ward of Ward Drilling Co., Inc. Marietta, Georgia.

SOLID CORE from a bucket drill in hard-packed formation. Photo by Calweld.

FOR SEVERAL YEARS, the drilled deep well has been the basic source of supply off the mains for increased fresh water demands. As with everything else, however, inflation has taken its toll, and labor costs, taxes, and increased prices for fuel, machinery, and supplies have forced the cost of drilling up.

At the same time, while the average home has a greater need for fresh water, the southeastern part of the United States, in particular, has witnessed a great growth of wholesale production of poultry and other livestock which further increased water demands in rural areas. These demands, too, are sensitive to prices.

It can be seen, then, that more and more water is needed and that costs must be kept down as much as possible. Enter the "bored well."

As used in the southeastern U.S., the term

Disadvantages:

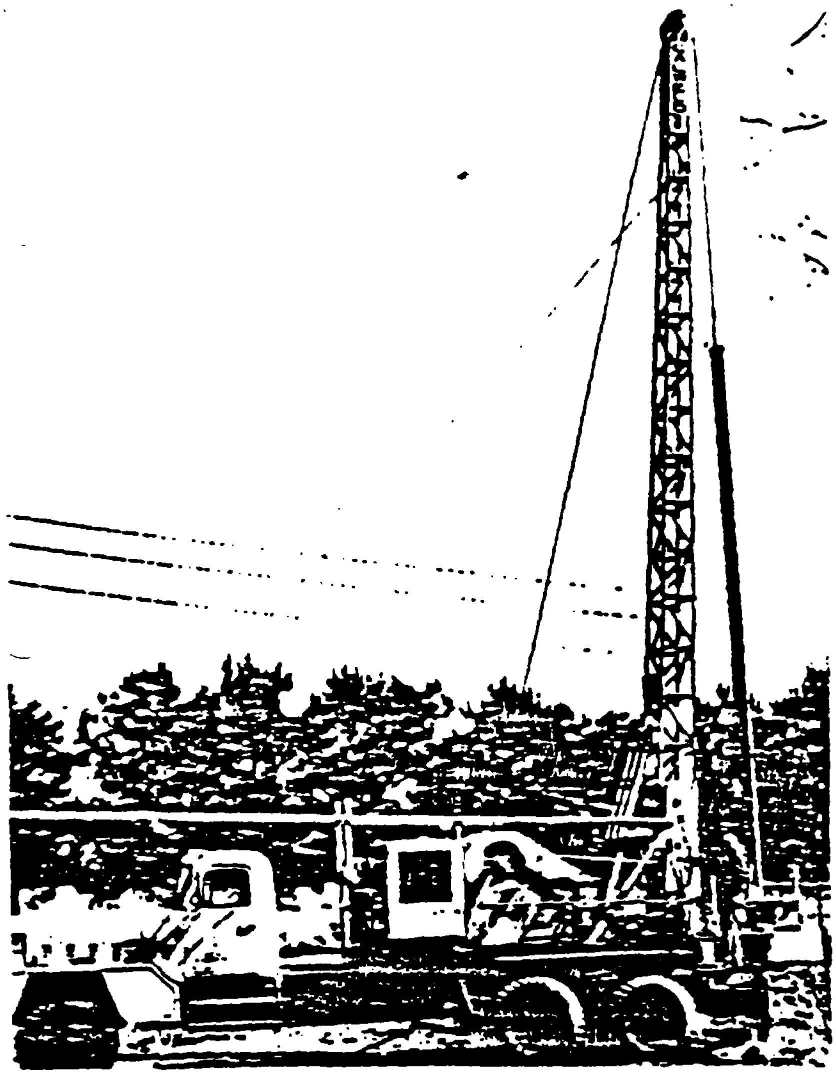
(1) A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.

(2) It is not possible to place a grout seal above the screen to assure depth-discrete sampling.

(3) The diameter of the casing is usually limited to two inches therefore, obtaining samples must be either by suction lift, air lift, bailer, or other methods applicable to small diameter casings.

(4) Jetting is only possible in very soft formations, and the depth limitation is shallow - say 30 feet without special equipment.

(5) Large quantities of water are often needed.

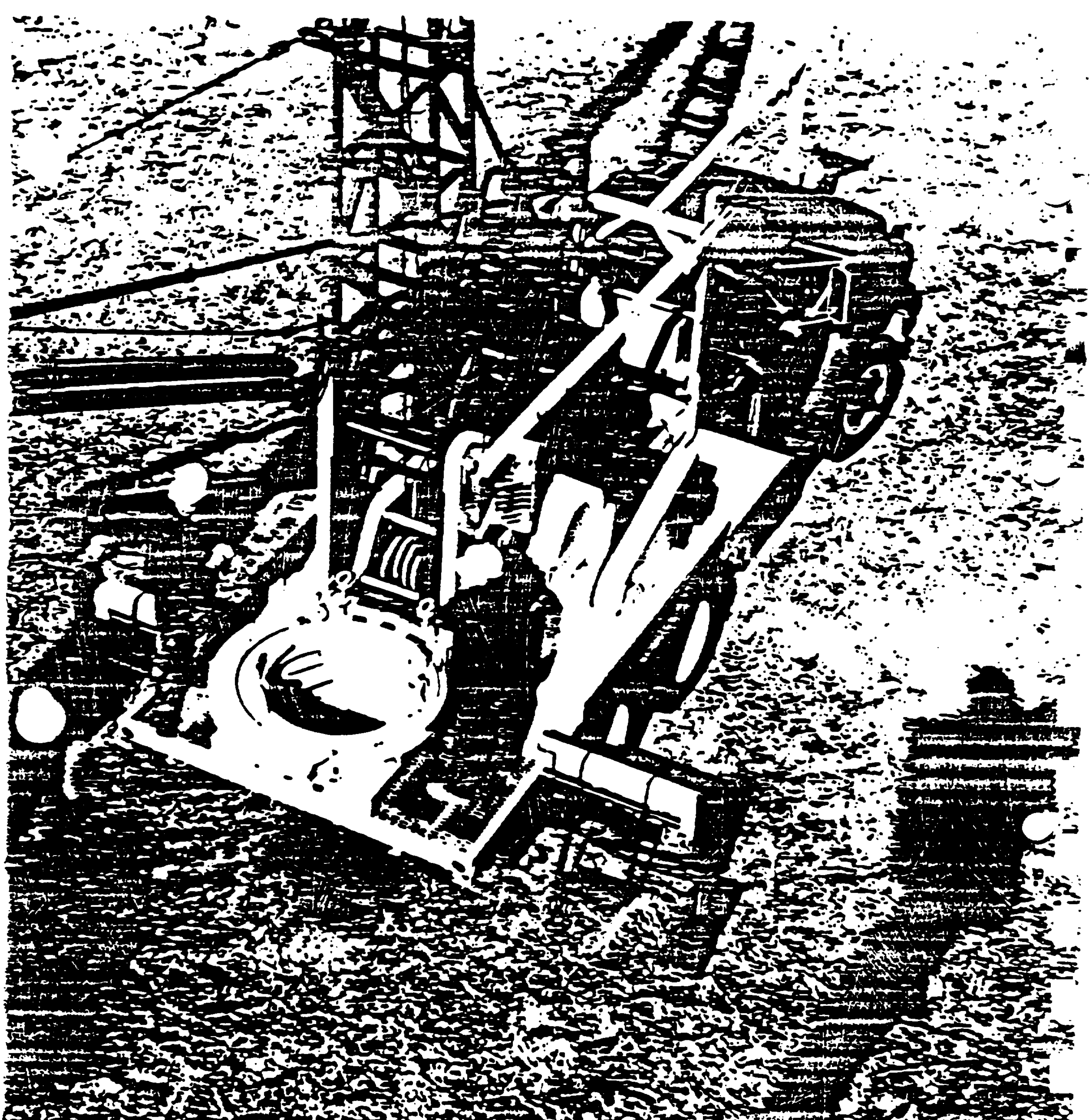


TRIPLE TELESCOPING kelly in the "dig" position. This rig, from Calweld Div. of Smith Industries, will handle 85 foot holes.

means the same as augering or rotary bucket drilling in other sections of the country. A bored well is one constructed by employing a bucket or auger type rotary machine. Such wells usually are about 30 inches in diameter and cased with 24-inch i.d. concrete pipe. The equipment is high-speed, volume-production machinery capable of making one to five wells per day, depending upon formations to be bored, well depths, travel distances, and so forth. This factor has helped hold the unit cost of boring relatively low compared with other methods.

To learn more about bored wells, let's follow the construction process from rig set-up to the water tap on the pump. First, however, a site is selected by agreement between the owner and driller. Several factors must be considered, but foremost is a location least likely to be or to become contaminated from any source of pollution, be it septic tank, barnyard, or other type of agricultural or industrial waste disposal. The site also must be as convenient as possible for the owner and (of course) within reach of the boring equipment. (The north Georgia mountains can produce some challenges in this regard.)

Once the site is selected, we put the ri place and prepare to level it and to raise mast, or derrick. Most boring rigs are equipped with hydraulic outriggers which lift both the machinery and the truck off the ground so that the rig can be levelled precisely for the boring oper-

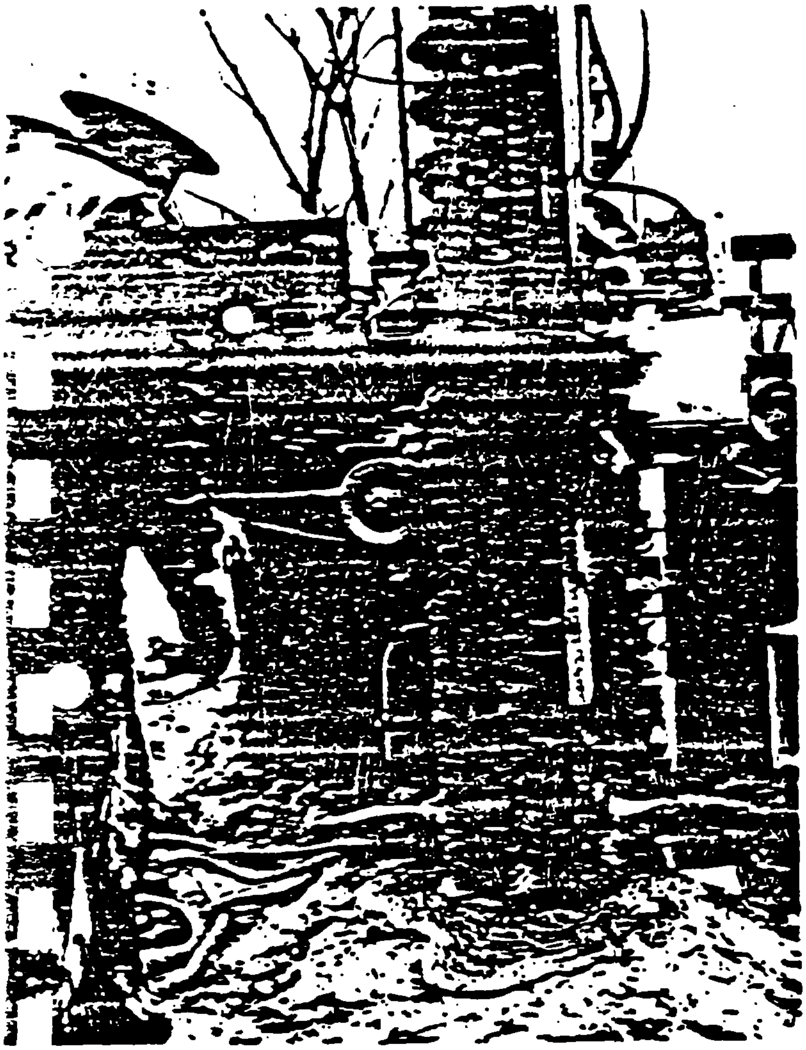


ation. When this is done, the mast is raised into position, also hydraulically, carrying with it the kelly bar.

Today, this kelly is often of the telescoping type and quite heavy, in our area usually from 4,000 to 5,000 lbs and 75 to 100 feet long when extended in the hole. Greater depths can be reached by adding lengths of drill stem between the kelly and the bucket, but when the rig has a telescoping bar, this is a time-consuming chore.

The kelly is supported by a steel cable connected to the machine draw works and is rotated by means of a large ring gear and pinion-type rotary table.

When the mast and kelly have been raised into position, and plumbed to the center of the ring gear opening, the boring bucket is attached to the kelly. This is a cylindrical device also known as an auger bucket. The entire kelly and bucket are then lowered to the surface of the ground



ACKER DRILL CO. augering rig which can be used fr hollow wells and sand drains.

and rotated so that the bucket teeth bite into the soil and scoop it into the bucket. (Thus the other term for this method: rotary bucket drilling.) The teeth are set in the bucket bottom at such an angle as to force the soil through slots in the bottom until the bucket is filled.

The principal use of boring for water wells is in unconsolidated formations. Standard equipment will not work on hard rock, although some few special rigs are built to order for consolidated formations. The buckets on these have specially hardened cutting surfaces.

A full cycle has the bucket and kelly lowered into the hole; the truck-mounted ring gear rotates the kelly and bucket downward until the bucket is full; the full bucket is raised to the surface, swung either to one side or to the rear of the rig and dumped; the bucket and kelly are returned to the hole for the next bite. This process is repeated until the hole depth reaches a water-bearing strata, usually sand or gravel and hopefully mixed with clay. Drilling continues then to a depth which will create a proper reservoir of water for peak demand within the well.

There is surprisingly little variation in the penetration rate between formations, provided they can be bored in the first place. For best results, the formation must be homogeneous; the work goes much slower when buried obstructions exist. Boulders or cobbles must be picked out of the bottom with a special tool, such as an orange peel bucket or stone tongs. Naturally, it takes time to attach such tools, remove the obstruction, and then replace the bucket.

Generally speaking, if you can bulldoze a formation, you can bore it with a bucket rig. Most commonly, areas with clay formations find bored wells predominating. With clay, the formation is least likely to cave in. Caving can be quite a problem in pure sand, although some drillers report success with boring rigs in sand by keeping the hole filled with water at all times. This stiffens the sand and keeps the walls from collapsing. It also is possible to case the hole as you go down in soft formations where cave-ins are a threat. You use a bucket with a reamer attachment which creates a hole of larger diameter than the bucket.

In our area, an auxilliary hoist line is employed to set concrete casing into the hole. The casing setter is manually tripped by means of a rope to release the first 3-foot sections of pipe. This apparatus then automatically positions and releases each successive length of casing pipe. To complete the construction process, grout is placed around the casing from the top, and a reinforced concrete cap is installed. The well is now ready for installation of the pump and connection to the distribution lines for the owner's use.

Where the formation is suited, bored wells can go fairly deep, but most importantly, they go quickly. On speed rests their economic advantages. From 30 to 40 feet per hour is not unusual, and many drillers regularly go down 60 feet per hour. These speeds would involve the use of a kelly only, since addition of drill rods or use of special tools for obstructions will take time away from boring.

Boring or augering or rotary bucket drilling can be the most economically efficient method available for large holes to a certain depth. How large and how deep will depend on local conditions and the experience and equipment brought to the job by the driller. ■ ■

Monitoring Well Design and Installation

by Robert C. Minning, Keck Consulting Services Inc.

Introduction

State and federal regulations require ground-water monitoring at existing and proposed hazardous waste facilities. Establishment of the monitoring network requires a thorough knowledge of the geologic and hydrogeologic conditions on-site and in the surrounding area. The necessary data can be collected from available information (i.e. area water well records, United States Department of Agriculture Soil Reports) or through a program of drilling and sampling and by surface geophysical surveillance. This paper will address common drilling and sampling procedures for hazardous waste facilities.

Variability of hydrogeologic conditions necessitates that a specific drilling program be designed for each site. Consideration of the study objectives and available technologies is critical for successful completion of the project.

Objectives of the Investigation

Prior to specifying a drilling technique for a project, the objectives of the work must be carefully evaluated. Objectives for consideration may include:

- Soils evaluation—if strict soil sampling and "undisturbed" samples are required (split spoon or shelby tube), the drilling technique must be capable of accomplishing the sampling.
- Determination of hydrogeologic conditions—the drilling technique should be capable of detecting zones of saturation throughout the boring, collecting accurate samples and installing observation/monitoring wells.
- Determination of the presence of ground-water contamination—the drilling technique should be capable of collecting ground-water samples at various intervals through the aquifer and must minimize potential cross-contamination.
- Installing permanent monitoring wells—the drilling method must accommodate well completion which may include gravel packing or grouting.

Site-Specific Considerations

The items listed below should be considered before deciding on a particular drilling method:

- Type of formation to be drilled—i.e. unconsolidated materials, unconsolidated materials with boulders, or bedrock.
- Site accessibility—length, width and weight restrictions may limit the drilling to the capability of the largest equipment which can access the site.
- Presence or potential presence of contamination—the method should minimize potential cross-contamination.
- Required well size—this is generally based on ease of sampling or strength of the casing. Large-diameter casing (greater than 4-inch) will require use of larger drilling equipment.
- Availability of equipment.

Drilling Techniques

This paper addresses only the most common drilling techniques. Auger drilling methods are most frequently used for hydrogeologic investigations; therefore, this method will be addressed in greatest detail. A comparative summary of the techniques is shown in Table 1.

Cable Tool Drilling

Cable tool drilling is a percussion method in which drill tools are used to break rock or disturb soils and drive the well casing. Drill cuttings are removed with a bailer or sand pump. Water generally needs to be added in the borehole to prevent heaving of unconsolidated materials. Once the hole is completed and the screen setting selected, the casing is jacked up to the appropriate depth and the screen is set inside the casing.

Table 1
Drilling Methods

	Cable tool	Mud rotary (conventional)	Air rotary	Auger-solid-stem	Auger-hollow-stem
Availability of equipment	Good	Good	Limited	Good	Good
Cost	Moderate $6-$10/ft.	Moderate to high $6-$20/ft.	High $12-$20+/ft.	Low $2-$5/ft.	Low $3-$9/ft.
Formations drillable	Most materials	Unlimited	Consolidated formations	Unconsolidated formations	Unconsolidated formations
Depth capability	Greater than 500 ft.	Unlimited	Unlimited	200± ft.	200± ft.
Hole size	Unlimited	Unlimited	Unlimited	Up to 14-inch	Up to 12-inch
Installing grout or gravel pack	Must double case hole	Easy	Easy	Grout only above water table	Grouting-easy gravel pack-difficult
Rig mobility	Good	Small rigs-good Larger rigs-poor	Poor-rigs generally large	Good	Good
Cross contamination potential	Good if fluids not used-may carry over on casing	Must double case to isolate fluids	Must double case	Difficult	Can isolate by grouting annular space
Quality of samples	Excellent-can get undisturbed samples	Fair to poor-can get undisturbed samples	Fair to poor-can get undisturbed samples	Good above water table-can only get undisturbed samples above water table	Good above water table-can get undisturbed samples

Sample collection is easy and accurate during drilling. Vertical sampling in an aquifer can be accomplished by setting a smaller well inside the driven casing (for unconsolidated materials). In an open bedrock hole, the section to be sampled should be isolated with packers.

Gravel packing or grouting a well requires that the casing driven be larger than the planned well. The well must be installed inside the casing, the gravel pack put in and the outer casing jacked out. Grout can be placed by installing a tremie pipe above the gravel pack and pumping the grout in after removal of the casing.

The major disadvantage of cable tool drilling is the time involved (especially in rock) for drilling a well. Care must also be used at contaminated sites to prevent cross-contamination from the drilling tools or the casing.

Mud Rotary Drilling (Conventional)

Mud rotary drilling involves rotation of a drill rod and a bit designed to cut through soil and rock. A drilling fluid is circulated through the drill rod and bit and up the annular space between the rod and the borehole. The drilling fluid is used to lubricate the bit, carry cuttings to the surface and maintain the hole. When the drill rod is removed, an open hole remains for setting wells, gravel pack and grout.

Soil samples recovered from the drilling fluid discharge are marginal for accuracy, mainly due to the loss of finer-grained materials. Undisturbed samples can be collected by pulling the rod from the hole and setting the sampling equipment.

Water samples can be taken at various depths in an aquifer by setting a small-diameter (2-inch) well, developing the well to remove drilling fluid and collecting the sample.

Rotary drilling is an excellent method for obtaining undisturbed soil samples at depths greater than 150 feet. Geophysical logs (gamma-ray, electric, hole caliper, single-point resistivity and temperature) are easily run in the open borehole and aid in the geologic interpretation.

The potential for cross-contamination by the circulating fluids is great. To alleviate this problem, the hole may have to be double- or triple-cased, with each string being grouted. This adds tremendously to the cost of the project. Circulating drilling fluid may also mask thin formations that can transmit ground water.

Air Rotary Drilling

Air rotary drilling works on the same principle as mud rotary, except that air is the medium for carrying drill cuttings to the surface. Because the air will not maintain an open hole, this technique is generally limited to use in rock formations.

The major advantage of air drilling is that water produced from the rock is carried to the surface, allowing evaluation of relative productivity of the various strata. In order to collect samples from specific aquifer zones, the desired strata must be isolated with packers.

Auger Drilling Methods

Solid-Stem Continuous Flight Augers

Solid-stem augers consist of auger flights welded to a solid core. Drilling is accomplished by rotation of the augers which convey soil samples to the surface. This type of drilling is generally used where shallow, lithologic descriptions are required.

Sample recovery is excellent in unsaturated conditions and undisturbed soil samples can be taken by removing the augers and sampling in the open hole. Sample collection below saturation is marginal because an open hole is not maintained by the augers. Wells can be set by pushing or driving a well into the zone of saturation. Vertical aquifer sampling and isolation of contaminated zones is impractical utilizing this drilling technique.

Hollow-Stem Continuous Flight Augers

A hollow-stem auger consists of flights welded to a hollow core which has a 1-1/2- to 6-1/4-inch inside diameter. The drilling technique is the same as the solid-stem augers with the exception that the core facilitates downhole sampling and well installation. This drilling method is most commonly used for engineering borings; however, since the monitoring well boom of the late 1970s, the hollow-stem augers are being widely used for intricate sampling and monitoring well installation.

Soil sampling can be accomplished by taking the auger cuttings from the unsaturated zone and undisturbed samples through the core of the augers. When running the augers open or pulling the drilling plug, it may be necessary to maintain a head of water or drilling fluid in the augers to prevent heaving of soils into the auger core.

Vertical ground-water sampling can be accomplished during drilling. One method to accomplish this is to install a temporary small-diameter (2-inch or less) well through the core of the augers and into the zone to be sampled. The well must then be pumped to clean any fine materials from the screen. After collecting the sample, the well can be pulled and the drilling continued. The casing may get sand-locked inside the auger which requires that the auger and casing be withdrawn and the hole redrilled. This sampling operation is nearly impossible under artesian conditions.

Keck Consulting Services Inc. developed an alternative method of collecting water samples vertically in an aquifer. This alternative uses a well screen incorporated in the core of the lead auger. The bottom of the auger is sealed with a PVC, Teflon or metal plug to prevent sand heaving. The core of the augers acts as a screened well.

During drilling, the augers can be checked for the presence of water. Once in the saturated zone, the auger core acts as a well and can be developed and sampled at specific intervals throughout the boring. The auger core can be evacuated with air, a bailer or a pump depending on the specific sampling requirements. Because a plug is installed in the end of the augers, undisturbed soil samples cannot be taken. The boring can be gamma-ray logged through the core of the augers to aid in geologic interpretation.

Care must be taken with the sampling equipment to prevent cross-contamination. There is potential for contaminant carry-over on the augers. However, with proper development, evacuation and sampling procedures, the method has proved effective for detecting organics to levels of two parts per billion.

The data collected during this drilling includes:

- Soils interpretation from auger cuttings;
- Productibility of saturated zones;
- Gamma-ray logs for delineating geologic strata;
- On-site water quality analyses.

Comparison of this data allows accurate interpretation of the hydrogeologic and chemical parameters of an aquifer so that monitor wells can be accurately placed for future monitoring. The monitor well can be installed through the augers by knocking the bottom plug out. During withdrawal of the augers, gravel packing or grout can be installed.

Conclusions

Geologic conditions and project objectives will dictate the type(s) of drilling needed to meet the job requirements. It is not always possible or cost-effective to use a single drilling method to complete a project. Thorough evaluation of the project requirements should be done prior to specifying a drilling method for the project. Bid specifications for a job should include the objectives of the project, restrictions that may apply (i.e. no drilling fluid), and any background data on site conditions. The returned bids should be carefully evaluated to determine technical capability to achieve the goals outlined. There are nearly as many drilling "tricks" as there are drillers and many of the methods are technically sound. These should be considered

Selection of Drilling Method, Well Design and Sampling Equipment for Wells to Monitor Organic Contamination

by Eugene E. Luhdorff, Jr. and Joseph C. Scalmanini, Luhdorff & Scalmanini, Consulting Engineers

In the course of ground-water investigations, including those designed to identify and correct or control ground-water contamination problems, some of the most important components are the drilling of boreholes for exploratory purposes, the completion of those or other boreholes into wells and the design and ultimate operation of wells for various purposes. Yet the attention paid to these components often seems cursory, thus allowing an element of question to enter regarding the accuracy of geologic or geophysical data, piezometric measurements and water quality samples. Equally as important, the cost effectiveness or, in certain extreme cases, the pure ability to accomplish the desired tasks become subject to serious question. This paper investigates improvements and innovations in drilling technology in the ground-water industry during the past decade which make available a vast assortment of techniques which, if properly selected, will provide efficient means to initially investigate ground-water quality and aquifer characteristics and to ultimately complete and operate monitoring or other wells. The paper further presents a methodology for rating several drilling methods based on their ability to achieve typical tasks in a ground-water quality investigation, and it illustrates the application of the rating system to two ground-water contamination problems in California.

Selection of Drilling Method

Objectives of a Drilling Program

After completion of the preliminary phases of a ground-water investigation, which might include review of existing data, surface geologic and geophysical exploration and collection of water-level and water-quality data from existing wells, subsurface exploration and investigation follow. The selection of a drilling method for this phase of work should be based on the ability and cost effectiveness of a particular method to accomplish the desired objectives of the drilling program. The objectives should be carefully defined prior to drilling in order to avoid costly and time-consuming frustrations resulting from the inability of a drilling method to penetrate the geologic conditions at the site or to attain the necessary information from the boreholes.

The objectives of a drilling program, or the tasks to be accomplished by a drilling program at any given site can include some or all of the following:

- The ability to physically penetrate all anticipated formations and materials at the particular site, to penetrate at a desired rate and to construct a borehole of desired diameter
- Identification of lithology, or development of a geologic log of all formations and materials penetrated to the desired depth
- Collection of samples of aquifer fluid during the drilling process and prior to well construction
- Geophysical logging of the borehole, ranging from electrical surveys to measurements of natural radiation, to determination of formation characteristics using sonic or radioactive tools
- Collection of "undisturbed" formation samples from the center line or sidewall of the borehole
- Containment of drill cuttings and fluids
- The ability to handle special conditions such as lost circulation, high pressure, flammable or toxic substances or other site-specific problems
- Completion of the borehole into a monitoring well during the initial construction process, i.e., constructing a well as the borehole is drilled or constructing a well in the borehole immediately after the drilling tools are removed
- Completion of a monitoring well in the borehole after a time lapse for interpretation of geologic and geophysical data collected from the borehole.

on their technical merit and evaluated for cost-effectiveness.

Biography of Presenting Author

Robert C. Minning is president of Keck Consulting Services Inc., Williamston, Michigan, and of Keck Geophysical Instrument Inc., East Lansing, Michigan. He received his B.A. in geology from Wittenberg University, an M.A.T. from Indiana University and an M.S. in geology/hydrology from the University of Toledo. He is a past chairman of the NWWA Ground Water Technology Division and has served on numerous committees. Prior to joining Keck he was an instructor in geology at Wittenberg University and Lansing Community College. Minning is a certified professional geologist by AIPG and in the state of Indiana. He has also served as consultant to the United Nations and World Health Organization.

Each ground-water investigation will have site-specific objectives among those listed above which can be used to select the best method of drilling at that site. In some cases, one objective may predominate and thus dictate a particular drilling method: in others, all the desired objectives might not be achievable and some compromise might be required either to reduce the objectives or increase the number of boreholes.

Drilling Methodology

The advancement of drilling techniques over the past decade presents a wide range of choices to those responsible for the selection of a drilling method in a ground-water investigation. The selection of the drilling procedure to employ on a project should be based on an analysis of a rig's capability to develop the specific exploration and well-completion requirements of the project.

Seven drilling techniques have been reviewed and relative values assigned to a series of objectives for each type of drilling procedure.

A detailed review of each drilling procedure is beyond the scope of this paper; however, a brief description of each type of operation follows.

1. Cable Tool Drilling

This procedure is the oldest method of well construction still widely practiced in the water well industry. The cable tool or percussion drilling method has been used for centuries throughout the world. It involves the raising and lowering of a string of drilling tools suspended on a drilling line in the well bore, followed by the bailing of the drilled cuttings from the hole. Generally, the well bore is kept open by the installation of a casing string as the drilling operation proceeds to the completion depth.

This practice of construction is usually much slower than the more modern rotary drilling techniques; however, the procedure has application in certain monitoring well applications.

2. Direct Circulation Mud Rotary Drilling

The introduction of direct circulation rotary well construction made possible the development of much of the world's oil resources. Adapted to water well construction in the early part of the 20th century, this drilling method allowed for more rapid construction of deeper wells for the ground-water industry. The practice employs a drilling fluid—normally a viscous fluid, heavier than water—which is circulated down a rotating drill pipe, through the drilling bit, returning up the annulus of the borehole, removing the drill cuttings in a settling pit where the fluid is again recirculated through the fluid system via a pump. Hole stability is accomplished by the hydrostatic pressure of the drilling fluid.

3. Reverse Circulation Rotary Drilling

The first unique drilling procedure developed by the water well industry was the introduction of reverse circulation drilling. The procedure of reversing the direction of flow—allowing the circulation of fluid from the bit up the rotating drill pipe to the settling pit—allowed for holes of larger diameters to be constructed. The integrity of the borehole is achieved by hydrostatic fluid pressures created by maintaining the hole full of water during drilling operations. The procedure reduced the need for specialized drilling mud control and reduced the development time required for normal mud rotary well construction completions.

4. Air Rotary Drilling

A second modification of conventional direct circulation rotary drilling is the use of compressed air as a drilling fluid instead of water or drilling mud. A high uphole velocity of air is used to remove cuttings from the borehole. While foaming agents and misting assist the driller in cleaning the hole, hole maintenance relies on the integrity of the formation to remain open during construction without the hydrostatic pressures present in conventional and reverse circulation drilling operations. This procedure is widely used throughout much of the northeastern United States and elsewhere in the country where consolidated formations exist, for domestic well construction.

5. Dual-Tube Rotary Construction

In order to obtain more precise control of the drill cuttings being returned up the hole, the air rotary drilling method has been refined by employment of a dual-tube drill pipe assembly. The drilling fluid (air) is sent down the drill pipe and the cuttings returned up the drill pipe in a second part of the "dual-tube." The practice is further refined by the use of a smooth outer drill pipe just slightly smaller than the hole diameter or bit diameter thus serving as a mechanical means of maintaining the integrity of the borehole. The drilling procedure has had wide application in the mining industry for material identification and for formation fluid sampling via air lift pumping.

6. Tophead Drive, Casing Hammer, Combination Rotary Rigs

Many rig manufacturers today provide drilling equipment which is capable of employing either air or drilling mud as the drilling fluid. In addition, some rigs are further refined to include tophead drive, casing hammer operations. Such a rig provides the ability to alter the method of construction to meet varying hole conditions encountered in the well. The use of a casing hammer allows casing to be installed through difficult drilling formations such as unconsolidated surface deposits and then returns to either air or mud circulation drilling for hole completion. The flexibility of the system does not provide the planner an endless freedom of choice in the random selection of drilling medium. Once committed to mud circulation, it is difficult to convert the system to air circulation in the same borehole. The rig flexibility allows the planner a first choice in drilling procedures.

7. Hollow Stem Auger Rig

While normally not considered a water well drilling rig, the hollow stem auger rig provides a means for construction of shallow piezometer wells commonly associated with monitoring projects. As the name implies, the rig configuration is normally a continuous rotary auger which is frequently used in soil foundation studies. The hollow stem in the auger drill string permits coring and water sampling during the drilling operation. In addition, small diameter casing can be installed through the hollow stem prior to removal of the drill string from the well.

Rating and Selection of Drilling Methods

To address the question of selection of the best drilling method for two recent ground-water contam-

Table 1
Drilling Method Rating System

Objectives	Cable Tool	Direct Mud Rotary	Reverse Rotary	Dual Tube-Air Rotary	Top Casing Drive Air/Mud	Air Rotary	Hollow Stem Auger
1. Identification of lithology							
A. consolidated formations	3-5	1-4	1-4	3-5	3-5	2-3	3-5
B. unconsolidated formations	3-5	1-4	1-4	3-4	3-5	2-3	3-5
2. Sampling of aquifer fluid							
A. non-volatile	3-5	1-2	0-2	2-5	3-5	1-2	2-4
B. volatile	3-5	1-2	0-2	0-1	3-5	0-1	2-4
3. Rate of penetration							
A. consolidated formations							
hard	1-2	1-3	1-3	2-4	1-4	2-4	1-2
soft	1-2	2-5	2-5	1-3	1-4	2-3	2-4
B. unconsolidated formations							
max size > 20mm	1-2	1-3	2-4	0-2	1-3	0-2	0-2
max size • 20mm	1-2	2-5	2-5	0-2	1-3	0-2	0-3
4. Ability to perform geophysical logging							
A. consolidated formations	0-2	5	3-4	0-1	0-5	0-3	0-2
B. unconsolidated formations	0	5	3-4	0-1	0-5	0-2	0
5. Ability to complete borehole into monitoring well during construction							
A. consolidated formations	3-4	3-5	3-5	1-3	3-4	1-3	0-3
B. unconsolidated formations	3-4	3-5	3-5	0-2	0-3	0-3	0-3
6. Ability to complete borehole into well following time lapse for log review							
A. consolidated formations	0-3	3-5	1-3	0-2	2-5	2-3	0-1
B. unconsolidated formations	0-2	3-5	1-3	0-2	2-5	1-2	0-1
7. Ability to obtain cores or sidewall samples	3-4	2-4	1-2	3-4	2-4	0-2	2-4
8. Ability to contain formation fluid and drill cuttings	3-5	3-5	0-3	3-5	2-4	0-2	3-5
9. Special site conditions							
A. lost circulation	4	2	1	5	4	3	1
B. high formation pressure (exceeding surface elevation)	0	5	0	2	4	0	0
C. flammable or explosive materials	3	5	3	1	4	1	1
D. toxic materials	3	5	3	1	4	1	1
E. other site-specific problems							

ination investigations and other ground-water quality investigations in California, a simple and direct rating system was developed to evaluate all the above drilling methods and their abilities to accomplish the objectives selected for each. For each objective or task, values from zero to five are assigned to each drilling method. A value of zero indicates the inability of the drilling method to accomplish a particular objective and, of course, precludes either that drilling method or that objective from further consideration. Other values are assigned as follows to qualitatively rate the drilling methods: 1—poor, 2—fair, 3—satisfactory, 4—good and 5— excellent. After assignment of values for all the objectives, the respective totals for the various drilling methods provide an indication of the best method for the particular job.

In some cases, a particular investigation may have one or more essential objectives. In such a case, the values assigned for those particular objectives can be inflated to "weigh" the selection of drilling method toward that which will best accomplish the essential objectives.

The rating and selection system is illustrated in Table 1 with values assigned to each of the seven drilling methods described above for the various objectives potentially desired in any ground-water investigation. The values included in Table 1 are typical of ratings or ranges of ratings which would be applicable to drilling with these methods in various geologic environments.

Well Design

Design of wells for monitoring ground-water quality can differ from well design for ground-water development and production. As in the case of selecting the best drilling method, monitoring well design can also be considered in terms of a series of objectives which the wells might be expected to achieve.

Monitoring wells generally are constructed for one or more of three purposes:

- Measurement of water table or piezometric surface elevations
- Collection of ground-water samples
- Determination of aquifer characteristics.

It can generally be concluded that all three of the above purposes require certain similarities to production wells: wells free of sand and turbidity, and wells properly sealed and developed to monitor formation fluids. Given those considerations, monitoring wells can be sized as a function of their purpose: a minimum of 1-inch in diameter for water level measurements; a minimum of 2 inches for water sample collection and a minimum of 6 inches for wells to be pumped for aquifer analysis.

If the initial drilling program, selected in a manner as described above, is to include well construction, a similar evaluation technique can be employed either to add the well construction requirements to those for drilling only (Table 1), or to consider the well construction objectives separately, which may result in more than one drilling method being employed on a project

Table 2
Monitoring Well Design Rating System

Design Requirements	Cable Tool	Direct Mud Rotary	Reverse Rotary	Dual Tube-Air Rotary	Top Casing Drive Air/Mud	Air rotary	Hollow Stem Auger
1. Piezometer single (1")							
A. consolidated	1	5	1	2	1–4	4	4
B. unconsolidated	1	5	1	2	1–4	1	4
Multiple piezometer in a single borehole							
A. consolidated	1	5	4	0	1–4	3	0
B. unconsolidated	1	5	4	0	1–4	1	0
2. Water samples single (2")							
A. consolidated	1	5	1	2	1–4	4	3
B. unconsolidated	1	5	1	2	1–4	1	3
3. Aquifer testing single casing (6")							
A. consolidated	3	5	4	0	4	4	0
B. unconsolidated	3	5	4	0	4	2	0
Multiple casings in a single borehole							
A. consolidated	1	5	4	0	0	1	0
B. unconsolidated	1	5	4	0	0	0	0

In the extreme, more than one drilling method may be employed on a single location: one method to satisfy exploratory objectives and a second to construct permanent monitoring wells.

The rating and selection system for well design, similar to that described above for drilling methods, is illustrated in Table 2. In this case, the values have the same qualitative ratings as used earlier and again, after application to a certain set of objectives, would allow for selection of the best equipment for monitoring well construction.

Applications of Drilling Method Selection Criteria

The selection procedures described herein have been effectively applied to two ground-water contamination investigations in California during the last two years. Both are briefly summarized below.

Case 1—Eastern Sacramento County

In the spring of 1981, it was determined that ground water in eastern Sacramento County had become contaminated. Organic and inorganic pollutants, including chlorinated organic chemicals, phenol, perchlorate, arsenic and sulfates had been found in concentrations exceeding the State and Federal drinking water action levels.

The State of California Water Resources Control Board commenced a program to construct test holes and monitoring wells in the affected area to obtain geologic, hydrologic and water quality information in order to determine the extent of the contamination and to monitor its movement.

The selected drilling sites were characterized by surface deposits of cobbles and other dredge tailings overlying unconsolidated sand and gravel formations. Drilling depths would range from 300 to 700 feet. All drilling sites were restricted to existing State of California property, normally located within freeway right-of-ways.

A summary of the evaluation of the drilling rig selection is illustrated in Tables 3 and 4. The work was successfully completed using a combination casing hammer, air and mud rotary drilling program.

Case 2—San Joaquin County

A large agricultural chemical manufacturer was required by the Environmental Protection Agency and the State of California to implement a program of investigation to determine if the source of ground-water contamination found in the area was attributable to its plant operations. The contaminants consisted of both inorganic and organic chemicals including pesticides.

A program of exploratory drilling was commenced to define lithology, obtain soil and water samples from the borehole and measure certain conservative quality parameters in each aquifer sample as drilling continued. The initial attempt to obtain the above samples employed the use of a hollow stem auger rig and a peristaltic pumping system. Drilling depths through uniform sand and clay formations were anticipated to be approximately 200 feet. Extreme difficulty was experienced in hole construction and sampling. As a result, the drilling program was evaluated using the method described above; the results are illustrated in Table 4. The drilling method was subsequently changed to meet the desired objectives and the work was successfully completed using a dual-tube drilling rig for soil sample collection and fluid sampling of the aquifer. Subsequent construction of monitoring well clusters (three or four individual wells per site), after construction and abandonment of all the exploratory holes, was successfully accomplished using direct mud rotary drilling.

Monitoring Equipment

Pumps

Much has been authored recently on the subject of extracting samples of water from monitoring wells. The amount of fluid that must be removed from a well casing to truly represent the water contained in the aquifer is still the subject of continued technical research. Those who have spent a number of years in the industry involved in pumping wells have experienced that a minimum of several casing volumes of fluid must be removed from a well to assure that the water being obtained represents the water in storage in the aquifer. The volumes to be removed from the casing should be increased both as the age of the well increases and the period of time between sampling increases.

To satisfy these concerns, two methods of providing pumping equipment for monitoring wells were adopted on specific projects in California on behalf of the Water Quality Control Board, the agency assigned the respc sibility of protecting the quality of water in the state.

One method involved the permanent mounting of small submersible pumps in a series of wells requiring monitoring. The submersible wiring was brought to the surface and terminated in a weatherproof junction box. The motor controller containing the relays and capacitor for the submersible pump was mounted on a portable switchboard which was moved from well to well with a portable generator. The system is designed to receive a teflon bailer to extract an aquifer sample following well purging by the submersible pump. The bailer is lowered into the submersible pump discharge piping to increase the reliability of the sample.

The use of a permanent pump in a well that will be sampled frequently, allows the investigator the opportunity to collect samples and to define aquifer characteristics through well testing. Water level measurements for testing or for monitoring can be obtained using permanently installed pneumatic transducers which are capable of providing instantaneous readout or continuous recording of water levels.

The second method of well purging required the development of a self-contained portable pump unit.

Case 1
Table 3
Drilling Method Rating System

Objectives	Cable Tool	Direct Mud Rotary	Reverse Rotary	Dual Tube-Air Rotary	Top Casing Drive Air/Mud	Air Rotary	Hollow Stem Auger
1. Identification of lithology							
A. consolidated formations							
B. unconsolidated formations	3	4	1	3	4	2	3
2. Sampling of aquifer fluid							
A. non-volatile							
B. volatile				NOT REQUIRED			
3. Rate of penetration							
A. consolidated formations							
hard							
soft							
B. unconsolidated formations							
max size > 20mm	1	2	2	1	3	1	0
max size < 20mm							
4. Ability to perform geophysical logging							
A. consolidated formations							
B. unconsolidated formations	0	5	3	0	5	0	0
5. Ability to complete borehole into monitoring well during construction							
A. consolidated formations							
B. unconsolidated formations				NOT REQUIRED			
6. Ability to complete borehole into well following time lapse for log review							
A. consolidated formations							
B. unconsolidated formations	3	5	1	0	5	1	0
7. Ability to obtain cores of sidewall samples				NOT REQUIRED			
8. Ability to contain formation fluid and drill cuttings				NOT REQUIRED			
9. Special site conditions				NONE			
A. lost circulation							
B. high formation pressure (exceeding surface elevation)							
C. flammable or explosive materials							
D. toxic materials							
E. other site-specific problems							
Totals:	0	16	7	0	17	0	0

Method Chosen: tophead drive, casing hammer with machined air circulation

The system consists of a submersible pump, hose reel, power winch, pneumatic transducer for water-level measurements, flowmeter and generator, all mounted on a portable trailer. Two men can install the submersible pump to a depth of 200 feet in approximately 15 to 20 minutes. The well can then be pumped until the desired volume is extracted from the well. Samples of the pumped fluid can be taken directly from the pumping unit or, if desired, the sample can be obtained by the use of a bailer. The portable equipment is also designed to conduct pumped well tests by providing measurements of the pumping rate, static and pumping water levels and total water pumped during the pumped period.

Case 2
Table 4
Drilling Method Rating System

Objectives	Cable Tool	Direct Mud Rotary	Reverse Rotary	Dual Tube-Air Rotary	Top Casing Drive Air/Mud	Air Rotary	Hollow Stem Auger
1. Identification of lithology							
A. consolidated formations							
B. unconsolidated formations	4	3	3	5	3	2	5
2. Sampling of aquifer fluid							
A. non-volatile	5	1	0	5	3	1	2
B. volatile							
3. Rate of penetration							
A. consolidated formations							
hard							
soft							
B. unconsolidated formations							
max size > 20mm	1	3	3	2	3	0	0
max size < 20mm							
4. Ability to perform geophysical logging							
A. consolidated formations				NOT REQUIRED			
B. unconsolidated formations							
5. Ability to complete borehole into monitoring well during construction							
A. consolidated formations				NOT REQUIRED			
B. unconsolidated formations							
6. Ability to complete borehole into well following time lapse for log review							
A. consolidated formations				NOT REQUIRED			
B. unconsolidated formations							
7. Ability to obtain cores or sidewall samples				NOT REQUIRED			
8. Ability to contain formation fluid and drill cuttings	3	3	0	5	2	0	3
9. Special site conditions							
A. lost circulation							
B. high formation pressure (exceeding surface elevation)							
C. flammable or explosive materials							
D. toxic materials	3	5	3	1	4	1	1
E. other site-specific problems							
TOTALS	16	15	0	18	15	0	0

Biography of Presenting Author

Eugene E. Luhdorff Jr. is a partner in Luhdorff and Scalmanini Consulting Engineers of Woodland, California, an organization specializing in ground-water hydrology, development and management. A registered agricultural engineer in California, Luhdorff has more than 26 years of experience in the ground-water industry as a water well contractor and consultant.

Luhdorff has authored several papers on water well construction practices and has lectured frequently in the University of California Extension system. He is past president of the Associated Drilling Contractors of California, the California Irrigation Institute and the Ground Water Institute. Additionally, he served as a director in the National Water Well Association.

APPENDIX 16-D

GUIDELINES FOR SAMPLING SUBSURFACE MATERIALS

MANUAL OF GROUND-WATER QUALITY SAMPLING PROCEDURES

by

Marion R. Scalf, James F. McNabb,
William J. Dunlap, and Roger L. Cosby
Robert S. Kerr Environmental Research Laboratory
Ada, Oklahoma 74820

and

John S. Fryberger
Engineering Enterprises, Inc.
Norman, Oklahoma 73069

ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
ADA, OKLAHOMA 74820

SECTION 7

SAMPLING SUBSURFACE SOLIDS

GENERAL REQUIREMENTS

A common misconception regarding ground-water monitoring is that absence of contaminants in the ground water precludes a contamination problem. In many cases, an effective evaluation of the potential impact on ground water quality of activities releasing pollutants into the earth's crust, requires samples of subsurface earth materials, both saturated and unsaturated, as well as ground water samples. There are several principal reasons for this requirement. (1) Only by analysis of earth solids from the unsaturated zone underlying pollutant-releasing activities can those pollutants which are moving very slowly toward the water table because of sorption and/or physical impediment be detected and their rates of movement and degradation measured. Almost all pollutants are attenuated to some degree in the subsurface, especially in the unsaturated zone. The degree of attenuation and rate of movement varies greatly between different pollutants and different subsurface conditions but many of the mobile pollutants may not be detected in ground water until the activities releasing them have been in operation for protracted periods. Because of their potential for long-term pollution of ground water, it is imperative that the behavior of these pollutants in the subsurface be established at the earliest practicable time. (2) Analyses of pollutants in subsurface solid samples from the zone of saturation are needed for a realistic evaluation of the total extent and probable longivity of pollution in an aquifer. Such analyses provide a measure of the quantity of pollutants which are sorbed on aquifer solids and which are in equilibrium with, and in essence serve as a reservoir for, pollutants in solution in the adjacent ground water. (3) Microbial populations which may be involved in the biological alteration of pollutants in subsurface formations are likely to be in such close association with subsurface solids that they will not be present in well waters in numbers which are quantitatively indicative of their presence in the formations; hence, analysis of subsurface solids are needed for accurate evaluation of such populations. (4) Even when the best well construction and ground-water sampling procedures are used, it is difficult to completely eliminate the possibility that contaminating surface microbes may be present in ground-water samples. Solids taken from the interior of cores carefully obtained from the zone of saturation probably provide the most authenic samples of aquifer microorganisms that can be obtained.

As with ground water samples, successful sampling of subsurface earth solids requires both acquisition of cores of subsurface solids at desired depths in a manner minimizing potential contamination and proper handling and processing of the core material obtained to insure its integrity and produce samples suitable for determinative analytical procedures.

Although tools for collecting soil or core samples have been used for a number of years in the foundation engineering and geology professions, core sampling for ground water quality investigations has received relatively little attention. There are undoubtedly many procedures developed for the foundation engineering, agriculture and petroleum industries that can be used or modified for ground water quality applications. This section of the manual presents some of the procedures that are currently being used.

ACQUISITION OF CORE SAMPLES

There are a variety of procedures and equipment that have been used to collect earth materials for classification and identification of physical characteristics. Tools as simple as a shovel or backhoe can and have been used and a number of designed samplers have also been used for this purpose. Because of the ability to penetrate greater depths and to maintain the physical integrity of the samples, most designed samplers employ some type of coring mechanism. The most common procedures use a thin-wall steel tube (core barrel) which is forced into the undisturbed soil at the bottom of a bore hole. This is sometimes refered to as drive sampling. Core barrels are generally from one inch to three inches in diameter and 12 to 24 inches long. When the core barrel is retrieved, friction will usually retain the sample inside, at least in most unsaturated materials.

The bore hole can be made with a continuous flight or hollow stem auger, rotary core drill or other drilling method. For water quality analyses, it is generally recommended that the drilling method employed avoid the use of drilling fluids since these greatly increase the potential for sample contamination. Similarly, it is also recommended that core sampling equipment avoid the use of drilling fluids.

Hand-operated soil sampling kits are commercially available that can be used at relatively shallow depths to both open the bore hole and collect a soil core. One such unit contains augers, coring tubes and sufficient drill rod extensions to sample to depths of twenty-five feet (23).

One widely used sampling device is a thin wall tube sampler illustrated in Figure 29. This device consists principally of a head unit threaded to fit standard drill rod and a replaceable thin wall seamless steel tube (23). The most popular tube size is 3 inches O.D. although sizes from 2 inches to 5 inches are available. In some subsurface materials, drag on the inner wall of the tube may cause considerable compression of the sample in unsaturated materials. To reduce this distortion and aid in keeping the sample in the tube during withdrawal from the bore hole, some investigators use a drive shoe on the bottom of the tube that has an inside diameter slightly less than that of the tube.

Another method of minimizing compression of the sample during coring is to wet the inside of the coring tube with distilled water immediately preceding the sampling operation.

Sampling in the saturated zone encompasses a number of additional problems of sample integrity. Maintaining an open bore hole while collecting a core

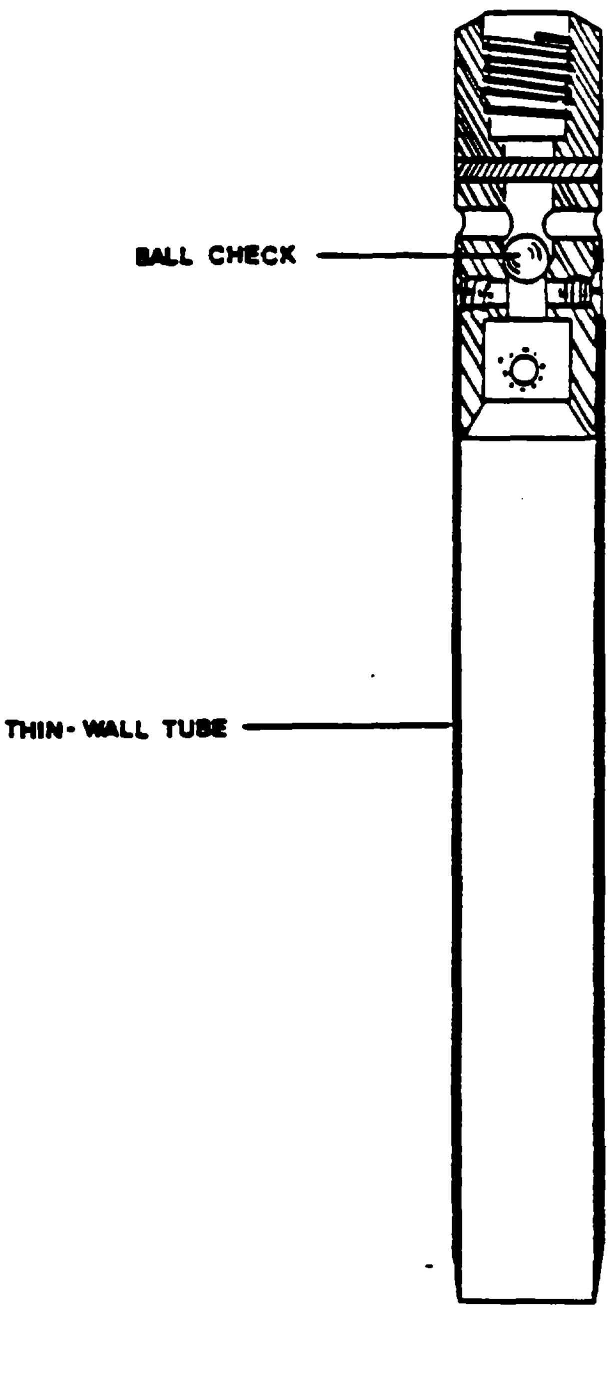


Figure 29. Thin Wall Tube Sampler (23)

sample is extremely difficult, especially in fine sand aquifers. Use of a hollow-stem auger can alleviate this problem in many situations but in extreme situations, removal of the augerplug may permit sand to flow up the interior of the auger before the core sample can be taken.

Sampling in a saturated zone also increases problems of contamination. The coring tube must travel through water in the bore hole and this water will almost surely contaminate at least the outside of the core sample. It is necessary, especially for microbial analyses, that the outside of the cores be discarded and that only the interior be used for sample analyses.

For deeper sampling, beyond the practical capability of augers, methods for collecting uncontaminated samples have not been proven. Air drilling with casing hammer offers the potential for opening a bore hole at the greater depths without drilling fluids. However, data is lacking at this time concerning the depth into the undisturbed bottom of the bore hole that is affected by the air drilling. Similarly, limited use has been made of a piston sampler for deeper sampling. The piston sampler employs a sample tube identical to the thin-wall core barrel but drilling fluid pressure is used as the driving force. The sampler sits on the bottom of the borehole at the end of the drill stem. A shear pin maintains the sample tube in an "up" position until a vent plug is dropped down the drillstem to the sampler. Pressure of the drilling fluid then shears the pin, forcing the tube through the bottom of the hole into the undisturbed material below the borehole. Considerable additional work is needed, however, to evaluate the extent of core contamination and to develop optimum methods for avoiding such contamination.

HANDLING AND PROCESSING OF CORE MATERIALS

The procedures to follow in processing a sample will depend on the type of analyses and the situation in the field. Regardless of the types of analyses to be performed, processing should be as soon as possible. When dealing with cores, the core may be processed in the field or if necessary the core may be retained in the core barrel, placed in a sterile plastic bag, sealed, and transported to the laboratory. This procedure works sufficiently well for cores of relatively compact, dry materials, but is not satisfactory for loose or very wet materials which will shift within the core barrel. Recommendations on storage of samples before processing vary widely from maintaining samples at the temperatures at which they are sampled to refrigerating them.

Split tubes or sectioned tubes are sometimes used to collect cores so as to permit access to the core material with minimal disturbance. Dunlap, et al. recommends a single piece coring tube and the use of a hydraulic extruding device when sampling subsurface solids for organics or microorganisms (12). As soon as the core is obtained, the drive shoe, if used, is removed and the sample tube is placed into the extruding device (Figure 30). As the core sample is forced out of the tube, the first 5 to 8 cm (2 - 3 in) are cut off with a sterile scalpel and discarded, or used for analyses of chemical or physical parameters. The center of the cores is then subsampled to obtain material suitable for microbial analysis by pushing a sterile 1.3 cm (0.5 in) I.D. stainless steel tube into the core for about 15 cm (6 in), as shown in Figure 31. The subsample is extruded with a sterile rod into appropriate containers.

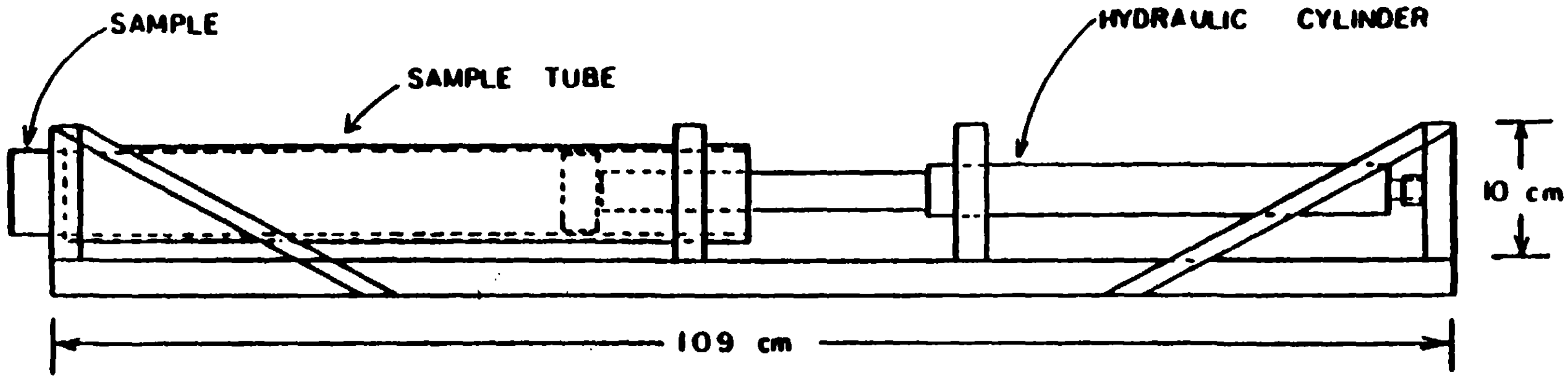


Figure 30. Core Sample Extruding Device (14)

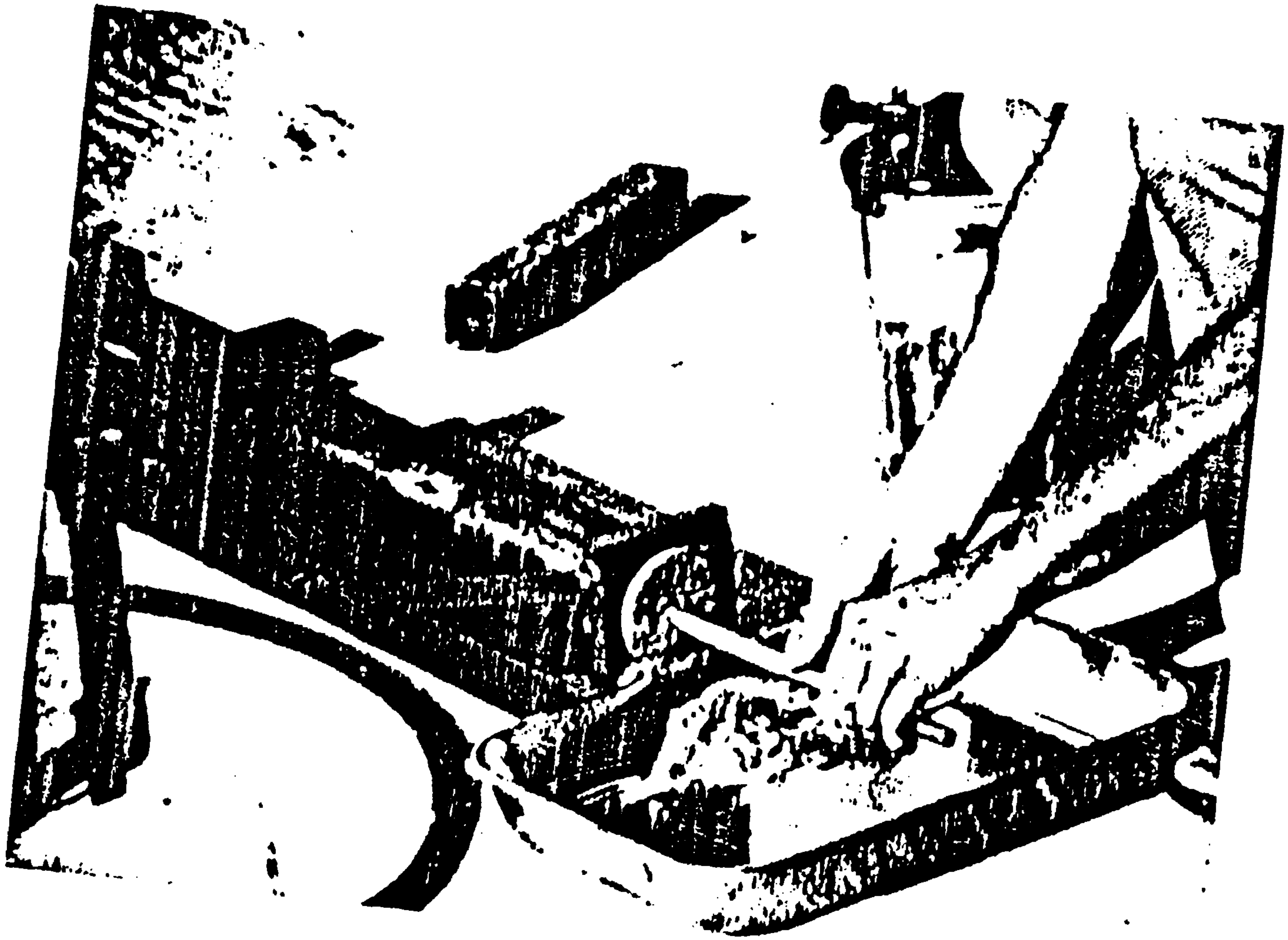


Figure 31. Subsampling a Soil Core (14)

The type of sample container which is used is dependent on the type of analysis to be performed. For culturing of aerobic organisms any sterile container is suitable if analyses are to be performed within a few hours. If there is to be a significant delay before the sample is used, care is exercised to keep the sample in a manner that prevents major changes in the microbial content. Polyethylene bags, which allow the passage of air but not water vapor, are good sample containers because the samples have access to air and yet are kept from drying.

Since subsurface environments of any depth are usually reducing in nature, the enumeration and identification of anaerobic microorganisms is essential if the total microbial composition of the system is to be known. Because many anaerobic bacteria are known to be extremely sensitive to oxygen, it is important that samples which will be used in anaerobic culturing procedures be handled in a manner that minimizes exposure to air. This can be accomplished by extruding subsamples into sterile glass tubes from which the air is replaced quickly with an oxygen-free gas.

Two methods have been utilized for air removal and replacement. In one method the sample tube is closed with a cotton plug and placed in an anaerobic jar from which the oxygen is removed either by catalytic means or by the use of a vacuum pump-replacement gas system (usually oxygen-free nitrogen). In the second method, the sterile glass tube containing the subsample is fitted with a gas-tight rubber septum stopper. A needle is pushed through the septum and the tube is evacuated with a vacuum pump and filled with a sterile, oxygen-free gas such as nitrogen. This process of evacuation and gas replacement should be repeated at least three times.

Samples to be analyzed for parameters such as biomass or viruses require specialized processing procedures which are continually changing as the state of art develops. Because such procedures are rapidly being improved, recommendations of any specific procedure are beyond the scope of this manual.

After a sub-core for microbial analysis has been removed from the parent core, a 10 cm (4 in) length of core material for chemical analysis is obtained. For organic analyses, the sample is extruded directly into a thoroughly cleaned disposable aluminum baking pan, covered tightly with clean aluminum foil, and placed in an insulated polystyrene box containing liquid nitrogen to quick-freeze the sample material. Typical locations for microbial and organic samples in a parent core are shown in Figure 32.

The frozen samples are returned to the laboratory on dry ice, stored temporarily at -45°C in a low-temperature freezer, and freeze-dried as soon as possible in a bulk type freeze dryer. Each sample of dried solids is carefully crushed and mixed to obtain a better degree of homogeneity. These samples are then transferred to thoroughly cleaned 475 ml (16 oz) wide-mouth jars with Teflon lined caps and stored at -45°C until subjected to further processing or analysis.

Samples of dried core material may be subjected to gross organic analysis, such as total organic carbon, without further processing. Samples suitable for more definitive analysis, including identification of individual compounds, are prepared by solvent extraction of the solid samples.

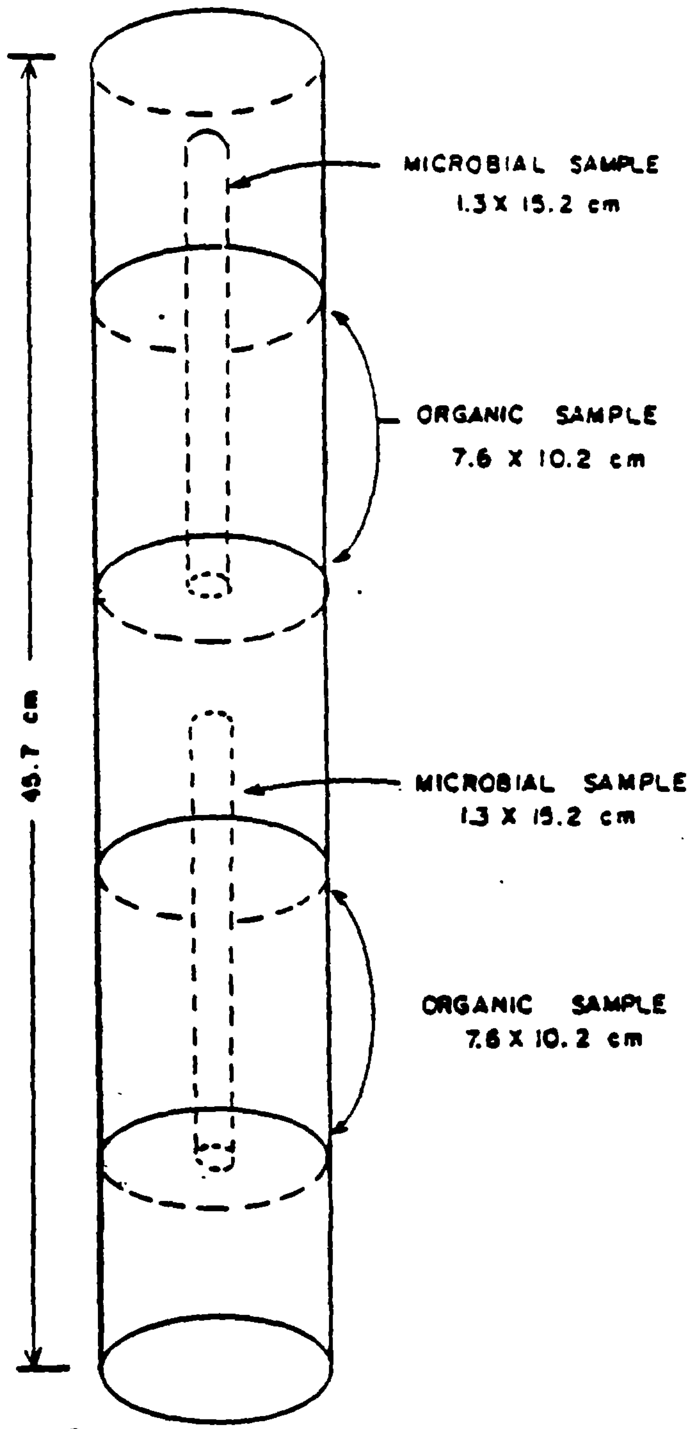


Figure 32. Typical Locations for Subsamples (14)

3

Detailed Explorations

ACCURACY A MUST

As we have seen from the foregoing section, the preliminary survey provides only the simplest of sub-surface information that in most cases will be further verified by more extensive tests.

The detailed exploration must yield accurate subsurface data which can be used for the design and cost estimates of the foundation. The detailed exploration program should be directed by a qualified soils engineer who is responsible for the foundation design, thus insuring that the necessary type and number of samples are obtained.

DETAILED BORINGS SAVE MONEY

Detailed borings should be so complete that no unforeseen subsurface conditions will be discovered when the excavation is started. The accuracy of the boring data will provide valuable assistance to the designer and contractor in estimating foundation costs. In the absence of accurate data, estimates by necessity will be on the high side. It is important in the overall design process to recognize that properly executed detailed test borings often pay for themselves by eliminating expensive overdesign in foundations and encourage realistic construction bids by foundation builders.

Still another benefit of accurate information is to greatly reduce the likelihood of large, unexpected and costly building settlements and the serious ramifications of foundation failures (Figure 56).

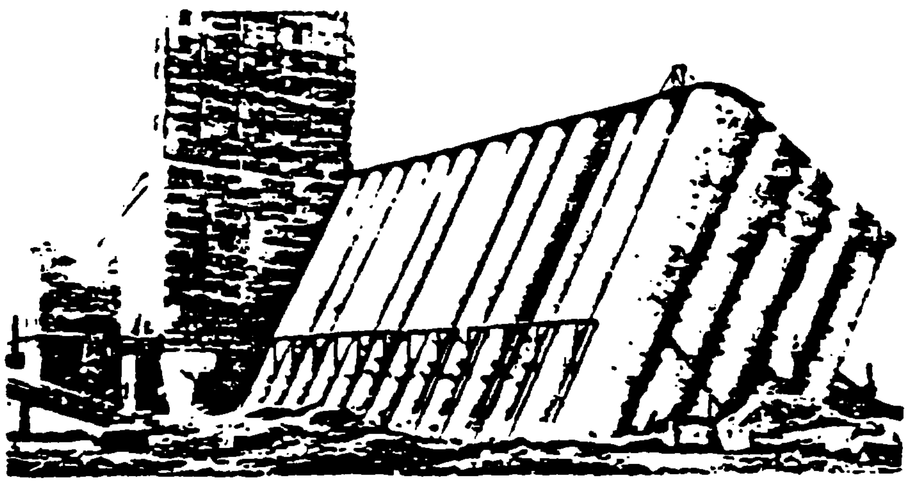


Fig. 56
A costly foundation failure

RESPONSIBILITY OF PERSONS SUPPLYING INFORMATION

For many years it has been the practice of the designer to provide the contractor with the results of all boring work and then wash his hands of all responsibility by inserting a paragraph to the effect that, "this data is supplied as a matter of information only and that the contractor must satisfy himself and assume his own responsibility for actual conditions encountered during construction". This is why some of the largest foundation builders maintain their own boring facilities. However, with the availability of reliable contractors using the latest equipment and techniques, such disavowal of responsibility has become increasingly rare.

In fact, the designer and boring contractor can and have found themselves involved in litigation. In the United States there seems to be an increase in the number of court cases involving foundation designers and contractors. Consequently, the need for accurate sampling and testing procedures has received new emphasis.

DEFINITION OF INFORMATION REQUIRED

The information that can be expected and required from detailed sampling varies with the location and the purposes for which boring are made. The following excerpt from a recent U.S. governmental specification clearly states the purpose of detailed borings.

"The intent and purpose of the work specified herein is to determine the type, nature and characteristics of the sub-surface materials and the extent and conditions of the various materials as they exist to the depths and at the locations specified for examination by means of observation well drilling and casing, undisturbed sample boring, drive sample boring and core drilling."

TWO TYPES OF DETAILED EXPLORATIONS

Detailed explorations fall into two broad classifications both of which are described more fully in the following pages. The first is drive sampling or dry sampling as it is sometimes called. It is made with a thick wall sampler and produces a representative but disturbed sample. It is used in all soil types.

The second classification is undisturbed sampling and is made with one of many thin-wall tube samplers available or with the Acker Denison Core Barrel. Samples obtained with these tools provide a minimum of physical disturbance and are known as "undisturbed" samples.

DRIVE SAMPLING (DRY SAMPLING) FOR DETAILED EXPLORATIONS

When detailed samples of cohesionless granular soils are required they are most frequently taken by a sampling method commonly called "drive sampling". Samples so recovered are not considered to be "undisturbed" samples but are known as "representative" samples. In practice, such samples are identified and classified in the field and then preserved in a moisture proof jar for further reference or laboratory testing.

It is possible to obtain "undisturbed" samples of cohesionless material but the methods are difficult, expensive and the sample obtained is hard to handle correctly in the laboratory testing process. Consequently, in-situ testing techniques such as the Standard Penetration Test or the static cone penetrometer are generally used for these soils.

Specifications for Drive Sampling

Specifications almost always call for either drive samples or undis turbed samples (the latter will be described later on) to be taken at fiv foot intervals of depth or as indicated by any intermediate change c material. In rare cases where some particular problem warrants th extra expense, samples are taken continuously from the top to th bottom of the hole.

The Technique of Drive Sampling

The sample is taken by actually driving a sampler or "sample spoon into the soil at the bottom of the bore hole—hence the term "driv sampling". This is shown diagramatically in Figure 57. The bore hol itself can be made by either continuous flight or hollow stem auger, rotary core drill or the wash boring technique of driving and jettin casing. The most commonly used methods are the wash boring and th hollow stem auger. The actual method employed, unless specified b the foundation engineers, is the cheapest method for any given site c area.

Common Spoon Samplers

Common sample spoons used for drive sampling are shown in Fig ures 58, 59, 60, 61, and 62. These samplers range in size from 2" out side diameter (OD) to 4-1/2" OD, the most popular being the 2 an 2-1/2" OD samplers. They are all available in either a 18" or 24 sample lengths. The 18" long sample length is generally more popula Also available is a connecting coupling which allows two samplers t be connected together for extra long samples.

Solid Tube Samplers

Figure 58 shows the simplest of the drive samplers. This Solid Tub sampler, as the name suggests, is merely a solid steel tube with a ba check valve in the head for venting and a hardened steel shoe fc driving. It has the advantage of simplicity and ruggedness. Its onl disadvantage is that the sample must be pushed out of the tube resultin in a broken-up specimen.

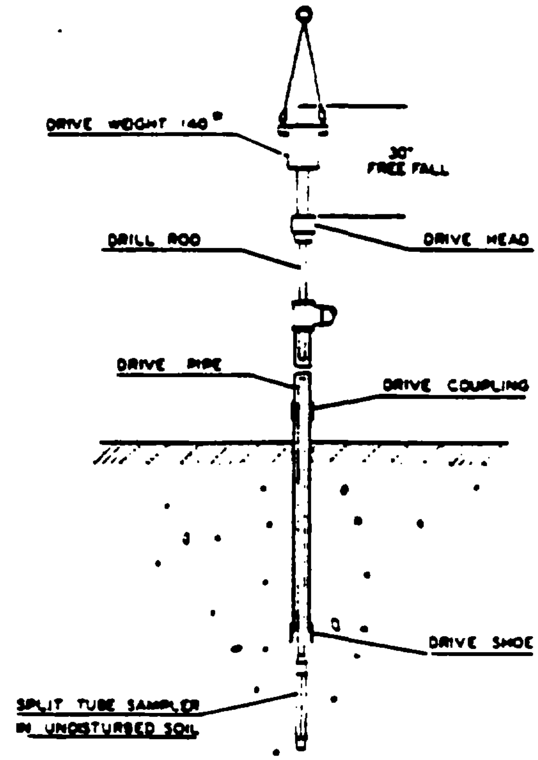


Fig. 57
Driving sample

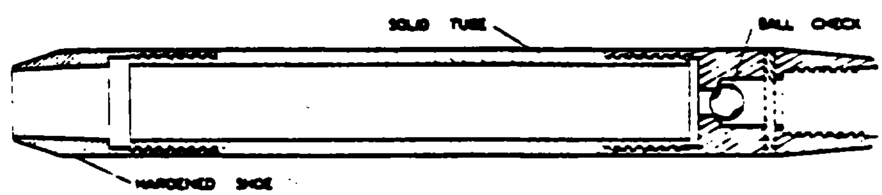


Fig. 58
Solid tube sampler

Split Tube Samplers

By far the most popular drive sampler is the split tube sampler shown in Figure 59. This tool has a ball check valve head and hardened steel shoe like the solid tube sampler, but the barrel of the sampler is split longitudinally. Thus, when the head and the shoe are removed, the barrel opens in two halves exposing the entire sample (Figure 60).

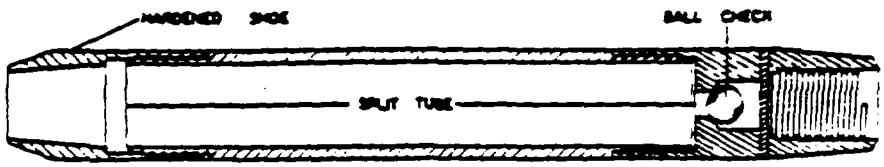


Fig. 59
Standard split tube sampler

Fig. 60
Split tube opened to expose sample

Split Tube Sampler with Liner

A popular addition to the drive sampler is an internal liner as shown in Figure 61. The barrel of the sampler is split longitudinally like the standard split tube and has a thin-wall brass, steel or paper liner inserted inside which will preserve the sample. After sampling the liner is sealed in a manner similar to a thin-wall tube sample: capped with plastic, aluminum or brass caps and coated over with wax. However, since the development of thin-wall samplers for use in cohesive materials the split tube with liner has declined in popularity.

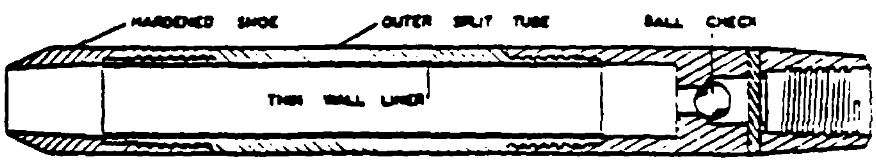


Fig. 61
Split tube sampler with liner

Acker Lynac Sampler—An Improved Split-Tube Sampler

A variation of the split-tube sampler containing all of the features of the standard split tube sampler but incorporating a thickened head section to better withstand the heavy pounding is the special Acker Lynac Sampler (Figure 62).

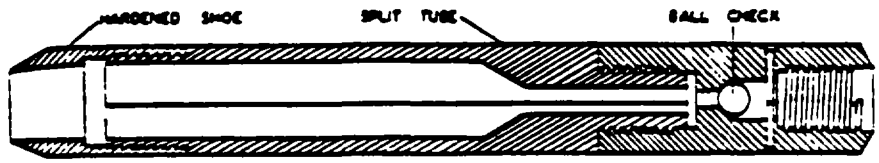


Fig. 62
The Lynac Sampler (U.S. Patent No. 2,795,395)

Sample Retainers

Before proceeding to the actual mechanics of drive sampling, it would seem informative to review three types of sample retainers which can be very useful in noncohesive materials. Figure 63 illustrates the trap valve, Figure 64 illustrates the spring sample retainer and Figure 65 illustrates the patented Lad sample retainer [U. S. Patent #3,008,529]. These can be used in any of the drive samplers described above. They are inserted inside of the sampler between the shoe and the sample barrel to help retain loose or flowing materials. The Lad sampler will even retain samples of flowing sands or other materials in a "quick" state.

Fig. 63
Trap-valve retainer

Fig. 64
Spring sample retainer

Fig. 65
Lad Sample Retainer
(U.S. Pat #3 008,529)

Driving the Sample

Once the hole has been completed to the proper elevation for sampling and has been properly cleaned to the sampling depth the string of tools shown in Figure 57 is assembled. These consist of a split tube sampler screwed to a length of drill rods. The sampler and rods are lowered into the hole. A drive head with guide or "jar length" is then attached to the top of the drill rods, which extend above the hole. The tools are now ready to be driven.

A drive or "drop" weight is used to drive the sampler into the undisturbed soil at the bottom of the hole. The sampler is usually driven to a depth which is 6" less than the length of the split tube sampler being used; that is, an 18" sampler is driven 12" and a 24" sampler is driven 18". Sometimes the sampler can not be driven the desired length, or in very soft materials the sampler will go down too easily necessitating extreme caution on the driller's part against over-driving and compressing the sample.

Fig. 66
Preserving split tube sample

Securing the Sample

When the sample has been taken, the drill rods with sampler attached are rotated two turns to shear off the sample. The drive weight is then used in reverse to bump the rods and sampler upwards and free them from the ground. After the sampler is raised to the surface, the split-tube is opened and the top and bottom layers of the sample are discarded. The remainder of the specimen is removed and sealed in an airtight glass sample jar and properly labeled (Figure 66).

The procedure outlined above is for drive sampling using any size sampler and any size drive weight. Drive weights up to 500 lbs. are used to drive casing while larger samplers are driven with wieghts up to 350 lbs. The most popular combination for drive sampling is the 140 lb. weight used with a 2" O.D. sampler. The reason is that this combination of tools is used for standard penetration tests.

STANDARD PENETRATION TEST FOR DRIVE (DRY) SAMPLING IN DETAILED EXPLORATIONS

Standard Penetration Test

As the science of soils investigation increased in scope, so did the practice of driving samples. It became evident that much useful information could be obtained by recording the number of blows required from a drop weight to drive a sample spoon a given distance. Various contractors and soils engineers developed their own standards for driving so that comparable results could be measured from job to job. Almost all specified driving a distance of one foot. But variations existed as to other factors. For example, some tests called for using a 300 lb. weight falling 18" and driving a 2 1/2" O.D. spoon. Some specifications called for a 300 lb. weight with a 3" O.D. spoon. Others specified a 140 lb. weight and either a 1-3/8" O.D. or a 2" O.D. spoon with a 30" drop.

As time went on, the use of a 140 lb. weight falling freely 30" to drive a 2" O.D. × 1-3/8" I.D. sampler a distance of one foot achieved general acceptance. Consequently these specifications became known as the Standard Penetration Test and are now part of the A. S. T. M. specifications for split barrel sampling.

How to Perform the Standard Penetration Test

Figure 67 shows a 140 lb. weight being used to drive a 2" split-tub sampler. After the sampler has been lowered to the bottom of the hol it is given a few light taps to seat it and make sure that it is in undi turbed soil. Then, the sampler is driven continuously for 18 inches. Th is accomplished by dropping the 140 lb. weight through a distance (30" over and over again. The number of drops or blows it takes to driv the sampler is recorded. Separate counts are made for the second inches of penetration and the third 6 inches with the first 6 inche considered to be a seating drive.

There are many conditions where due to the consistency of the so the 140 lb. weight will not drive the sampler the full 18 inches an refusal is reached. A. S. T. M. specifications define refusal as "a penetr tion of less than 1 ft. for 100 blows."

The standard penetration test using the 2" O.D. split tube sampl has become a regular and accepted method for all drive samplin Results so obtained are used to classify the soil in accordance with th chart shown in Figure 68.

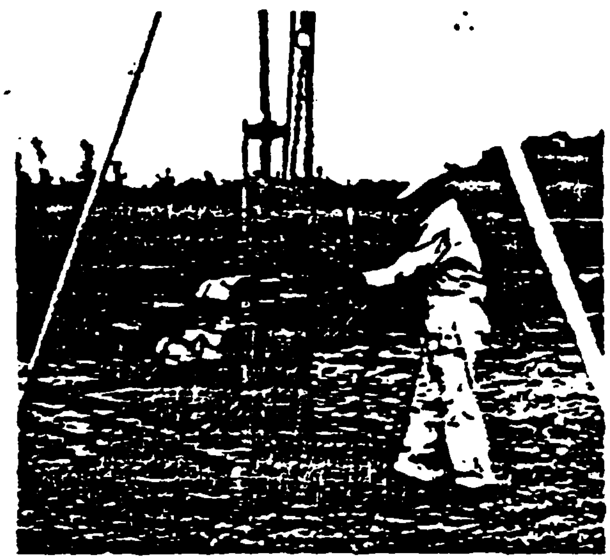


Fig. 67
Standard penetration test with Acker Ace "C"

Interpreting the Results

The classifications shown in Figure 68 are taken from the building code of a large U. S. city and are used with a second chart, Figure 69, to define satisfactory bearing materials. Although the recommendation, selection or design of footings are beyond the scope of this text, the compilation shown in Figure 69 is presented as a matter of interest and evidence of the practical value of the drive sample and the standard penetration test.

STANDARD PENETRATION TEST CORRELATION CHART

Sampler 2" O.D. x 1⅜" I.D.
Hammer 140 lb., 30" fall

Soil	*Designation*	*Blows/Ft.*
Sand and Silt	Loose	0 - 10
	Medium	11 - 30
	Dense	31 - 50
	Very Dense	Over 50
Clay	Very Soft	Less 2
	Soft	3 - 5
	Medium	6 - 15
	Stiff	16 - 25
	Hard	Over 25

Fig. 68
Standard penetration chart

CLASSIFICATION OF SUPPORTING SOILS

Class	Materials	Max. allowable presumptive bearing values in tons per square foot
1.	Hard Sound Rock	100
2.	Soft rock: hardpan overlaying rock	12
3.	Very compact sandy ground	10
4.	Compact sandy gravel: very compact clay sand and gravel: very compact coarse or medium sand	6
5.	Firm sandy gravel: compact clay, sand and gravel: compact coarse or medium sand: very compact sand-clay soils: hard clay	5
6.	Loose sandy gravel: firm coarse or medium sand	4
7.	Loose coarse or medium sand: compact fine sand: compact sand clay soils: stiff clay	3
8.	Firm fine sand: compact inorganic silt: firm sand-clay soils: medium clay	2
9.	Loose fine sand: firm inorganic silt	1½
10.	Loose sand-clay soils: loose inorganic silt soft clay	1

Fig. 69
Classification of supporting soils

UNDISTURBED SAMPLING FOR DETAILED EXPLORATIONS

Undisturbed Sampling Defined

The term "undisturbed" sample is relative and somewhat of a mis mer, since no sample is completely undisturbed. In soils usage it come to mean a sample that has been recovered in such a manner t its physical structure and properties are unchanged from what tl were in the ground. As such, there must be no distortion or contami tion of the sample. The soil structure, water content and configurat of the individual strata must be carefully preserved.

The Problems of Distortion and Contamination in Undisturbed Sampling

Distortion and contamination of samples are caused by difficult sa pling conditions, but most of these can be avoided by careful procedu and the right equipment. Additional disturbance of the original sam often occurs in the removal and handling of the specimen between the field recovery and the laboratory testing. Emphasis should be pla on the transportation and adequate shipping containers used for unc turbed samples as these must protect the sample from extremes temperature and movement (freezing and bumping). There will alw be some disturbance if for no other reason than the stress release c to bringing the sample to the surface, but much of the man m disturbance can be easily avoided by paying more attention to details involved.

Testing Cohesive Materials

When cohesive materials are encountered in soils explorations, i generally mandatory for successful foundation design that an accur evaluation of the shearing strength of this material be made. This m be accomplished by performing one of several laboratory test on "undisturbed sample", or by performing a vane shear test on the s in the ground.

Accepted Undisturbed Samplers

Aside from special samplers that are available, the following represent the most popular and widely used "undisturbed samplers".

1. The Shelby Thin Wall Tube Sampler (Figure 70)
2. The Stationary Piston Sampler (Figure 77)
3. The Acker Denison Sampler (Figure 80)

The basic similarity between all three samplers is that in operation they all recover a sample by pushing a *thin* tube into cohesive soil. The tube is removed with the sample intact. Sealing the tube and sending it to the lab for analysis completes the procedure. Actually, there is quite a difference in the construction and the use of all three, and it will be worthwhile to consider each sampler separately.

The Thin Wall Tube Sampler

The simplest and most widely used of all three tools is the Thin Wall Tube Sampler shown in Figure 70. This sampler consists of a thin wall tube secured to a head containing a ball check valve. The head is threaded to receive standard drill rods.

The bottom of the tube is rolled inward to provide an inside clearance of approximately 1% of the diameter. In practice, the edge is actually turned in more than this and is then reamed-out with a special reamer so that a sharp cutting edge is achieved. In this way, a controlled clearance is obtained reducing the drag on the inner wall of the tube and the consequent distortion of the sample. Since most cohesive soils have a tendency to swell during sampling, the 1% restriction assists in retaining the sample as it is withdrawn from the bore hole.

The ball check valve in the head section vents the inside of the tube to the outside, permitting the rapid escape of air or fluid above the sample as the tube is pushed downward.

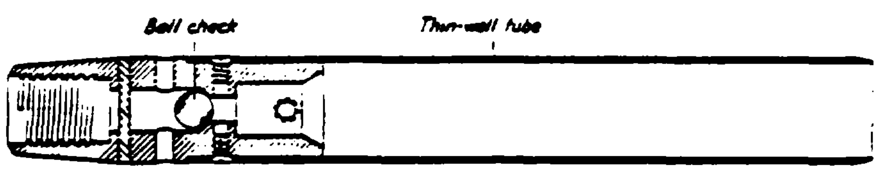


Fig. 70
Thin wall tube sampler

Standard sizes of the thin wall sampler are shown in the accompany ing table, Figure 71. Tube length is generally 24" or 36" long, althougl longer or shorter tube lengths are made for special applications.

Steel, Brass and Stainless Steel Tubes Available

Thin wall tube samplers are usually made from commercial grad seamless steel tubing. But when a long delay between the field recover of the sample and actual laboratory testing is anticipated, or where th soil under investigation is of an organic nature such as peat, it i advisable to use brass or stainless steel tubes in place of the steel.

Brass and stainless steel tubes are, however, more expensive and hav a greater tendency to deform when compared to steel tubes. Brass an stainless steel tubes are available in the same sizes as standard stee tubes.

By far the most popular tube size is 3" O.D. with 2" O.D. next. A will be explained later, these are used in a cased drill hole. The 2" O.D tube is used in BW casing. The 3" O.D. tube is used in 4" HW casing

Where 5" O.D. and larger samplers are required, the Thin Wal Sampler is manufactured from 11 guage, the thinnest commercial tub ing available in this diameter.

The thin wall sampler and its use have become so popular that the have now been established as an ASTM standard. These sizes are show in Figure 71.

ASTM THIN WALL SAMPLER TUBE SIZES

OUTSIDE DIAMETER		INSIDE DIAMETER		WALL THICKNESS			TUBE LENGTH	USED IN
INCHES	MM	INCHES	MM	GAUGE	INCHES	MM	[illegible]	CASING SIZE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	63.5	[illegible]	[illegible]	[illegible]	[illegible]	1.65	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	73.0	[illegible]	[illegible]	1.65	61.0	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.65	67.3	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.65	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.05	[illegible]	[illegible]

[illegible]

Fig. 71
Thin wall sampler tube sizes

UNDISTURBED SAMPLING WITH THIN WALL TUBE SAMPLERS

How to Take a Thin Wall Tube Sample

The Thin Wall Tube Sampler is used in virgin, undisturbed soil below the bottom of the casing. Many specifications call for a program of dry samples and undisturbed samples at five foot intervals or at any change of strata. When the driller has either reached this five foot limit or noted a change of strata, either through change in the hardness of driving or color and consistency of the return wash water, he stops driving the casing. The hole is then cleaned out to just below the bottom of the pipe in preperation for taking the undisturbed sample. It is important that the driller know the exact depth in order to positively fix the elevation of the sample.

Cleaning the Casing with Jet Augers

In materials that wash away easily or absorb water rapidly, one of the two types of clean-out jet augers shown in Figures 72 and 73 are recommended. These augers are rotated at the end of a string of drill rods. A flush helix at the bottom of the auger tends to peel the soil encountered in the casing upward. Water jets faced upward catch the soil and wash it to the top of the hole.

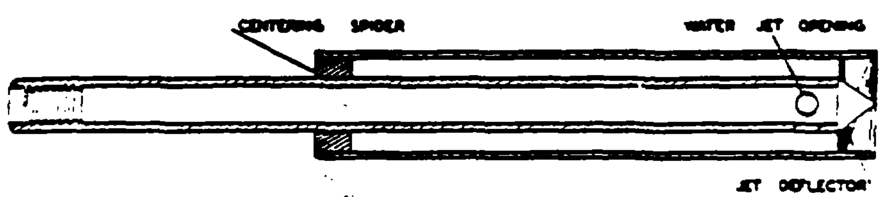


Fig. 72
Clean-out auger

When material inside the casing consists of broken pieces too big to be washed to the surface, a clean-out auger with a sludge barrel is used (Figure 7·. The sludge barrel catches the broken pieces and when it is full, it is returned to the surface and emptied.

The advantages of these methods of clean-out are obvious. (1) The soil below the pipe is not subjected to the hydraulic action of the standard chopping bit. (2) The stratum to be sampled is exposed in a relatively clean, undisturbed condition.

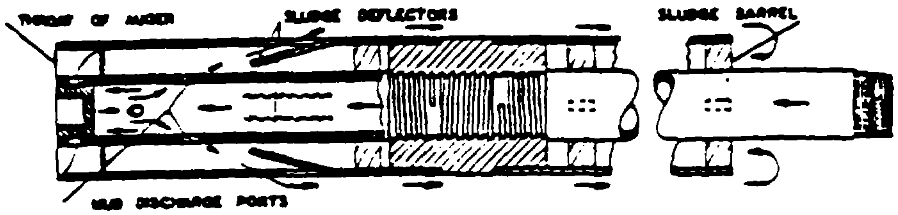


Fig. 73
Clean-out auger with sludge barrel

After the cleaning operation is completed, the Thin Wall Tube Sampler is screwed on the end of a standard string of drill rods and lowered into the hole. The top section of the drill string is allowed to protrude at least two feet above the casing pipe.

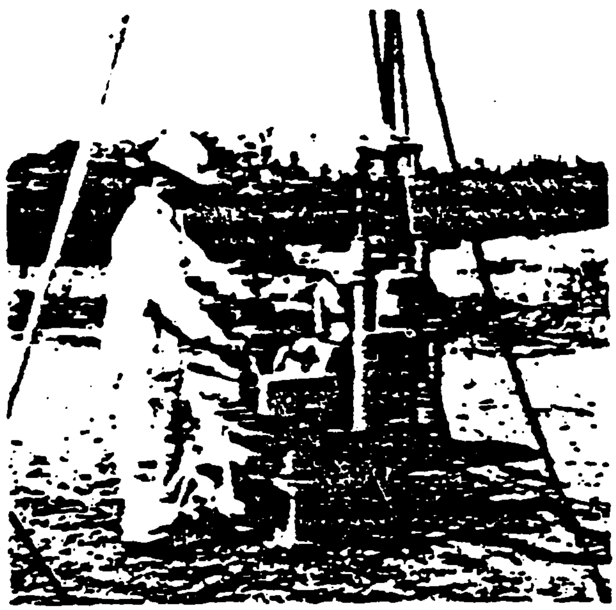


Fig. 74
Acker Ace pressing thin wall tube sampler

Pressing the Sample with a Hydraulic Core Drill

When the sampler is in contact with the soil at the proper elevation, the sampler can be pressed into the undisturbed soil. The object, regardless of the method used, is to force the Thin Wall Tube downward with one fast smooth stroke. The easiest and best method to do this is with a hydraulic feed core drill having a two foot stroke (Figure 74). This enables the sample to be taken under controlled conditions, and the pressure required to push it downward can be read on the hydraulic guage.

Sampling Difficult Soils

Occasionally, very stiff clays of hardpans are encountered which simply cannot be sampled by pressing in a thin walled tube. These formations can be tested with an Acker Denison Core Barrel (described later). A less satisfactory method is to drive a Thin Wall Tube Sampler with a drive weight rather than pressing. While this method introduces greater chances of distortion, it has some acceptance as a field expedient.

Prevention of Overtravel Important

To prevent overtravel in the pressing operation, a stop or indicator mark should be used. To recover the sample after pressing, the drill rods at the top of the hole are given two full turns to the right to shear off the sample and break the vacuum. The entire string is then retrieved from the bore hole.

The sample is retained in the tube due to the skin friction on the inner sides of the sampler and the vacuum above the sample created by the ball chech valve.

Retaining Samples in Cohesive Materials

In some cases where the material is not cohesive or "sticky" enough to stay in the tube, the situation can be improved by waiting anywhere from five to thirty minutes before withdrawing the sampler. Most cohesive materials have a swelling characteristic and this time interval gives the soil an opportunity to be expanded above the 1% restriction at the bottom of the tube, and also allows it to gain in shear strength so that it adheres to the tube more.

Sample Tube as Container

When the sampler with sample intact has been brought to the surface and disconnected from the drill rods, the tube itself is removed from the head by withdrawing the holding screws (Figure 75). This tube section is used as a container to protect the sample in transit to the laboratory, or for storing for further testing. An inch or two of material is removed from the top and bottom ends of the sample and a sealer such as bee's wax or paraffin is poured in hot to prevent loss of water content (Figure 76).

Both ends of the tube are now capped with close fitting copper, aluminum or plastic caps. The caps are secured to the tube with friction or plastic tape and waxed over.

Identify Each Sample

Each sample is numbered as to hole and elevation and any other pertinent data given. Although it is best to conduct lab tests as soon as possible, properly prepared thin tube samples can be stored for a considerable length of time without harm to the sample. Whenever long storage is contemplated or organic materials are involved, brass or stainless steel tubes should be used.

Fig. 75
Thin wall tube removed from head

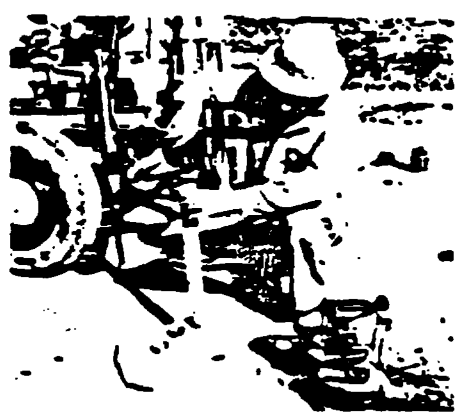


Fig. 76
Sealing thin wall tube

UNDISTURBED SAMPLING WITH STATIONARY PISTON SAMPLER

The development of the Stationary Piston Sampler was a natural outgrowth of the use of the Thin Wall Tube Sampler. As shown in Figure 77, the construction of the "Stationary Piston Sampler is similar to the Thin Wall Tube Sampler except for the addition of a sealed piston and a locking cone in the head to prevent the piston from moving downward.

Advantages

By referring to Figure 77, it can be readily seen that the Stationary Tube Sampler has two principle advantages: (1) It is fully sealed at the bottom so that it can be safely lowered through fluid and soft cuttings without fear of sample contamination. (2) By holding the piston station- ...d pushing the sampler downward, the top of the sample is com- ...ei protected from any distorting pressure at the top. Thus, a much ... effective vacuum seal is maintained than with the ball check valve ...he Thin Wall Tube Sampler.

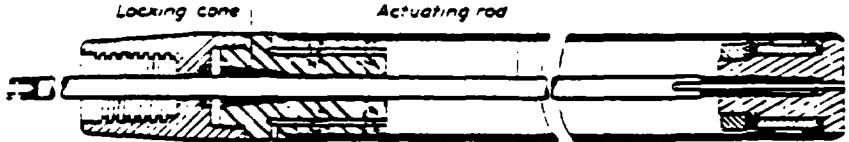


Fig. 77
Stationary piston sampler

Operation of the Stationary Piston Sampler

The hole is prepared in the same manner as it was for sampling with the Thin Wall Tube Sampler. The Stationary Piston Sampler is placed on the bottom of the hole with the piston flush with the bottom end of the thin wall sample tube. The actuating rod is held in place (see Figure 78) and the sample tube is pushed past the stationary piston. The tube

is then removed from the hole and separated from the sampler a
paratus. The actuating rod (see Figure 78) must be unscrewed a fe
turns uncovering a vent hole to release the vacuum before the tube c
be removed from the head. Once the tube has been removed, it is seal
and stored just like the thin wall tube sampler. (In fact, once they a
removed from the head the thin wall tubes are identical and inte
changeable.)

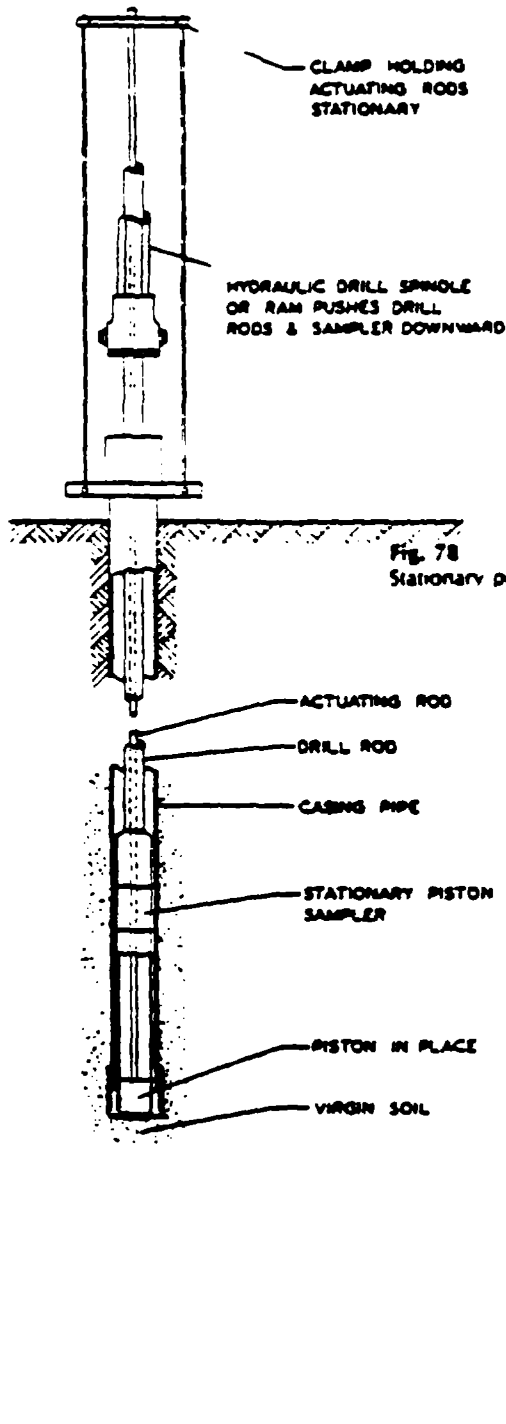


Fig. 78
Stationary piston sampler set to press sample

Improved Version of Stationary Piston Sampler

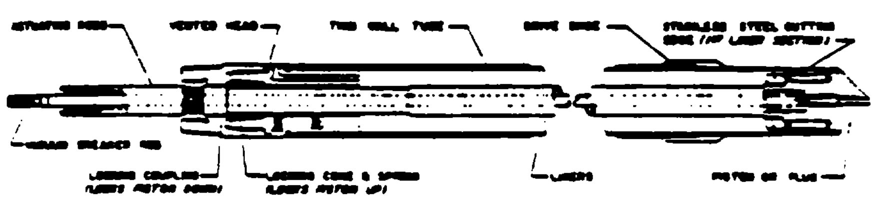
There are several variations of the standard Stationary Piston Sampler. The improved Lowe Acker Stationary Piston Plug Sampler, shown in Figure 79, is worthy of mention. This sampler represents an advance in both design and the use of imporved materials. Standard size for this device is 3 1/2" O.D. and it is called the Modified 3 1/2" Stationary Piston Plug Sampler.

Advanced Design Permits Operation in Uncased Hole

As the name implies, the improved sampler combines the features of the Plug Type Sampler with the Stationary Piston Sampler so that the piston can be locked in either an up or down position. When the piston is locked in the down location, it is possible to use the sampler without casing. Locking the piston in the top position insures against movement after the sample is taken, thus insuring that the sample is not lost.

Improved Materials Extend Life of Sampler

This sampler also features a permanent steel barrel with plastic liner and a thin, elongated cutting shoe. The plastic liners that permanently retain the sample are tough, light and inert. All in all, this is a more rugged, heavier duty sampler than the thin wall tube sampler or the standard stationary piston sampler. It is particularly useful in deeper sampling of heavy clays or where tidal or other conditions make it difficult to maintain casing.



3 1/2" LOWE - ACKER PISTON PLUG SAMPLER

Fig. 79
Lowe-Acker piston plug sampler

UNDISTURBED SAMPLING WITH DENISON SAMPLER

The Denison Sampler

The third type of sampler generally accepted as a tool for undisturbed soil sampling is the Denison Sampler or Denison Core barrel as it is sometimes called. This device was developed and patented by H. L. Johnson of Denison, Texas, and was first used by the Denison District, Corps of Engineers, U. S. Army. Hence, its name Denison Core Barrel. Subsequent to its introduction it was used extensively by various districts of the Corps of Engineers and by the Soil Conservation Service, U. S. Dept. of Agriculture. As its success has become more widely known it has achieved general acceptance by soil engineers, foundation designers and consultants.

Acker Drill Co. holds exclusive manufacturing rights to the Denison Core Barrel under U.S. Patent #2,403,002.

Denison Succeeds in Difficult Soils

The Denison Sampler is a valuable additon to the two types of thin wall tubes samplers previously described and serves the purpose of making it possible to recover an undisturbed sample where the thin wall sampler or piston sampler can not operate advantageously, i.e., in hardpan, hard clays, highly cemented soils or extremely stiff deposits. In this type of material the pressure required to push or even drive the thin wall sampler is so great that it causes distortion within the sample or physical damage to the tube itself resulting in a lost sampler or in some cases abandonment of the hole.

The design and construction of the Denison Core Barrel are shown in Figure 80. Basically it is similar to that used in rock drilling but with a thin lined inner tube adapting it to soils use. However, there are other design features which will help explain its great success in difficult soils.

In Figure 80, notice how the inner tube and cutter bit always preceed the rotating outer tube into the formation guaranteeing the sample will be undisturbed and uncontaminated by the drilling fluid. The oversize free floating rubber menbrane vent valve provides rapid and unhampered evacuation of air or other fluid above the sample yet gives instantaneous and positive sealing of the sample chamber when the sampler is withdrawn. Also, it can be noticed that the inner sample tube is vented directly to the low pressure upstream area on the outside of the

Denison Core Barrel. The pressure differential between this area and the downstream circulating flow tends to float the sample. This is particularly important in loose or saturated sands and sediments. In these cases by using a heavy circulating mud a sample can by recovered

Fig. 80
Denison Core Barrel

where everything else fails. Figure 80 also shows the inner liner of tl Denison's non-rotating core tube. This liner insures that once the sa ple is recovered it is never contaminated or physically disturbed duri removal from the sampler. Once this liner is removed, it should treated just like a thin wall sample tube and should be sealed or stor in a similar manner. Also in Figure 80 it is easy to observe the lar fluid and vent passages.

Four Standard Sizes Available

The Denison Core Barrel is manufactured in four standard siz 3 1/2" O.D., 4" O.D., 5 1/2" O.D., and 7 3/4" O.D. and recover relatively large sample in the inner non-rotating tube of the barrel. T inner tube is lined with very thin steel or brass liners so that the sam can be recovered and preserved in the same manner as when us Shelby thin wall samplers or stationary piston samplers. Stand lengths recover either two foot or five foot samples with the shor barrels recommended for softer materials. The Denison Core Barrel be operated by any standard drill rig capable of using NW rods or lar and is suitable for use with either clear water or drilling mud (Fig 81).

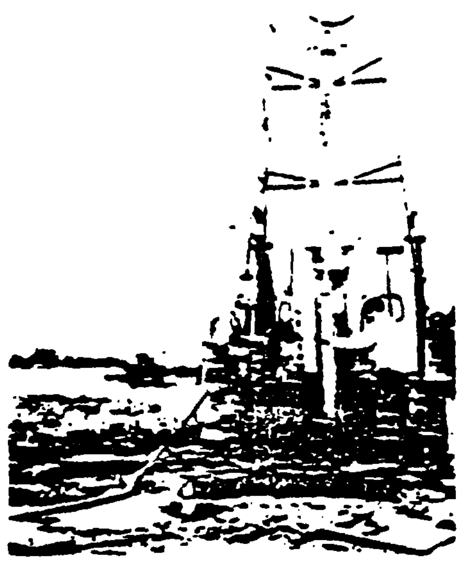


Fig. 81
Lowering Denison core barrel into the hole, note recirculation pit for mud.

How the Denison Operates

In operation, the Denison Core Barrel is rotated into the soil either in a cased hole or a hole stabilized with a drilling mud. The inner barrel is a full swivel type mounted on antifriction bearings. This barrel protrudes below the cutting bit carried by the outer barrel. The purpose of this protrusion is threefold: 1) To insure that the sample is recovered from material undisturbed by cutting action of the rotating bit, 2) To seal off the sample from water or drilling fluid discharged at the bit face and, 3) To protect the sample from deformation by preventing any rotative drag on the inner barrel. This inner tube remains stationary at all times.

As the Denison Core Barrel is forced downward with gradually increased pressure, the sample passes through the core retainer into the inner barrel and the thin walled liners then act as permanent containers for the sample.

Two Types of Core Retainers Available

Two types of core retainers are used: either the split ring type, Figure 82, for harder materials, or the basket spring type, Figure 83, with thin flexible springs for soft soils. In the small size Denison Core Barrel (3 1/2" O.D.), it is sometimes possible to omit the core retainer altogether and rely on the skin friction of the inner tube to retain the sample. The bore of the inner tube is made to provide a slight clearance so that as the sample swells after entering the barrel, it will tend to be retained by wall friction.

Fig. 82
Denison core barrel with carbide bit and core lifter

Fig. 83
Spring type basket retainer for Denison Core Barrel

Larger Samples Obtained

Because of the large size of the Denison sample, there is less dist(tion than found in the smaller thin tube samples. This larger specim can be trimmed in the laboratory to remove a thin deformation zc caused by wall friction or the slight drag of the core retainer sprir and leave sufficient volume to prepare several large size samples.

The Denison Core Barrel Successfully Samples Soft Shale, Clay, Gravel, etc.

The Denison Core Barrel has also been successful in sampling m tures of gravel and clay, in soft shale, and weathered rock interla with clay seams. By using different bottom assemblies, it is possibl(properly apply the sampler to a fairly broad field of applicaticn. I soils applications, the extension of the inner tube below the bit face be varied from 1/2" to 3 1/2", depending upon the consistency : hardness of the material under test. In softer material a greater ext sion is needed to hold the inner barrel motionless and prevent ba wash, but in harder formations only the 1/2" extension is nee When an extremely compact formation is encountered, the Deni Core Barrel is fitted with a regular bottom discharge bit assembl either carbides or diamonds and conventional split ring core li (Figure 82).

IN-SITU TESTING

Vane Shear Testing

Technically, vane shear testing is not a sampling process sinc physical sample is recovered. However, its extreme accuracy (v conducted properly with good equipment) and simplicity of oper: has increased the use and popularity of this method, particular cohesive soils.

Vane shear testing is a quick and fairly simple way of getting in j shear strength data of cohesive materials, such as soft or medium clays, silts, loams, etc. The shear strengths themselves can be e obtained right at the site. It is suggested that whenever vane : testing is done extensively, it is good practice to take several u turbed samples to provide positive identification of the soil and a la tory confirmation of the vane results.

The Vane Shear Process

In vane shear testing, a vane (Figure 84) is rotated in a cohesive formation and the torque necessary to shear the soil is measured in inch pounds. As the vane is rotated it shears a cylindrical section of earth and it is a simple matter to compute the unit shearing strength of the soil in pounds per square inch once the total applied torque is known.

Correction Chart Makes Results Easy to Read

Since each size vane has a characteristic geometry, a chart such as that shown in Figure 85 is available for each size so that the soil shearing strength can easily be picked off for any given value of input torque. Frictional drag of the operating mechanism is disregarded since most vane equipment is constructed with anti-friction bearings.

Many correlations have been made between vane shear tests in the field and physical samples tested in the laboratory, and it is reassuring to know that shear strengths found in the field from vane testing follow closely those found in the laboratory.

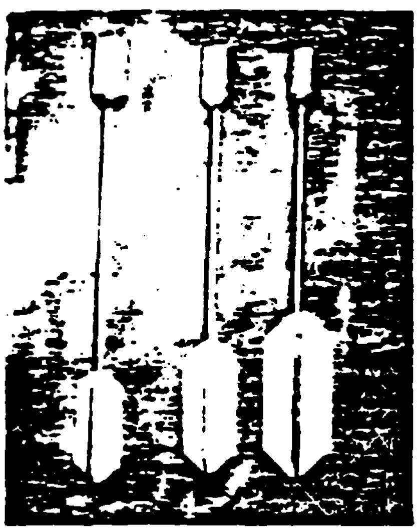


Fig. 84
Vanes for vane shear testing

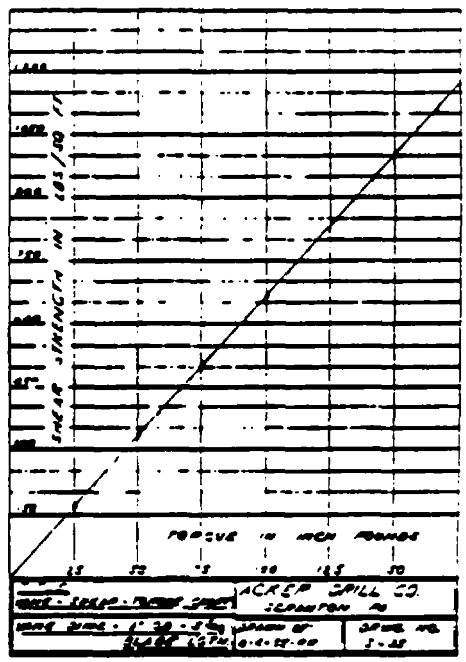


Fig. 85
Vane shear torque chart

A Clean Casing is Important

Vane shear testing is carried out in cased bore holes. The method advancing and cleaning the casing is the same as described in sections on drive sampling and undisturbed sampling with the Th Wall Tube Sampler and the Stationary Piston Sampler. As it is imp tant that the vane be rotated in an undisturbed soil, the final clean before testing should be done carefully and, preferable with one of two types of clean out augers shown in Figures 72 and 73.

Typical Assembly for Testing

Figure 86 shows an assembly of a typical vane shear test set up. vane itself is attached to a standard string of drill-rods with ball-bear guide couplings spaced at 25 foot intervals to overcome friction betw the rods and the casing. The entire string of tools is supported o thrust bearing at the top of the pipe. The vane is rotated from the with a torque wrench applied to the drill rods.

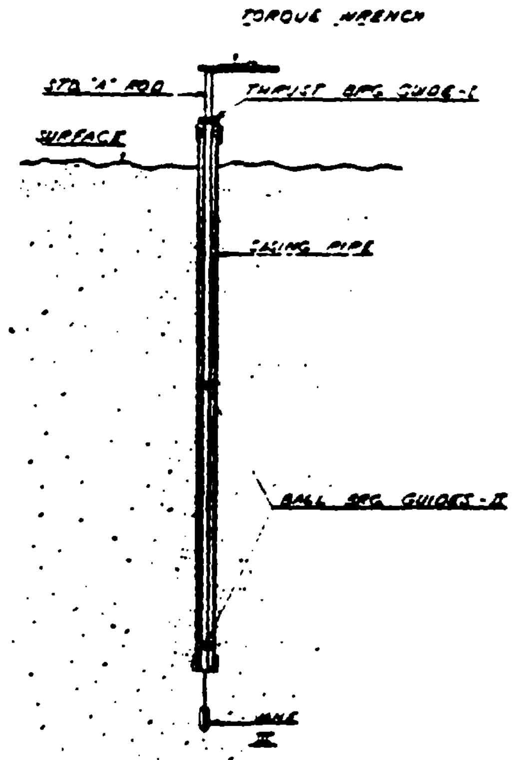


Fig. 86
Schematic of a vane shear test

How to Do an In-Place Shear Test

For in-place shear testing the vane is pressed one to two feet into cohesive material below the casing with no rotation and as little disturbance as possible. The vane is tappered top and bottom to make it easier to press and withdraw (Figure 84). When the vane is properly positioned it is slowly rotated (Figure 87) and the torque as well as the total angular rotation to produce failure of the soil carefully noted.

The shear strength of the soil is then picked off a torque chart corresponding to the applicable size of the vane being used. (See Figure 85)

Fig. 87
Turning precision torque head on vane shear

Package Kit Available

Figure 88 shows an Acker Vane Shear Test Kit containing three sizes of vanes and one set of ball-bearing guides with bushing for use in either 2 1/2", 3" or 4" casing. Two torque wrenches with different ranges are included for improved accuracy over a wide range. In very soft materials having a low shear strength the larger size vane with a low range torque wrench is used. The smaller vane and the larger wrench are employed for heavier clays.

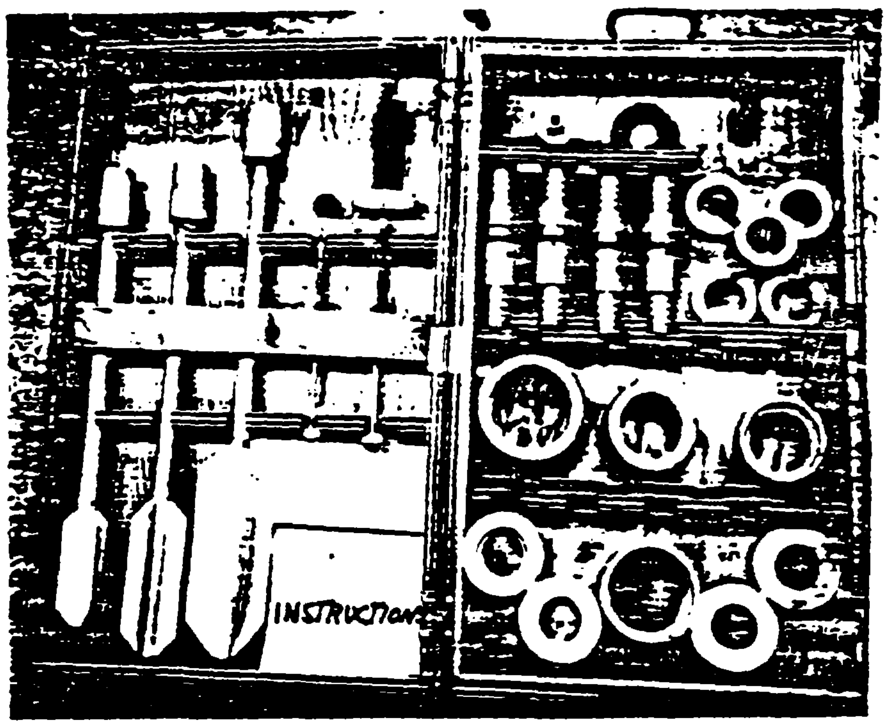


Fig. 88
Acker vane shear test kit

Precision Torque Head for Precision Results

Where greater accuracy or an extended program warrants addition equipment expense the extremely accurate torque head shown in Figu 89 can be substituted for the manual torque wrenches. This head bo to the top of the casing and supports the tools on a thrust bearir Torque is applied through a lever arm and proving ring type for guage.

The ball point of the force guage is pressed against the torque arm through a system of gearing with a 720 to 1 ratio so that two rotations of the handle by the operator turns the vane one degree. Angular rotation can be ascertained very accurately and turning effort applied at an even rate. The torque arm has three positions with corresponding scales recommended for either soft or hard materials.

In practice this equipment is used the same way as the simpler set up with the torque wrench except that readings of applied force are taken at determined intervals of rotation (usually 5°–10°). The force guage is of the maximum reading type that does not automatically return to zero. In this way the maximum torque applied is automatically indicated when shear failure occurs.

The torque head provides a greater degree of accuracy than the conventional equipment, yet utilizes the same vanes and correlation charts previously shown.

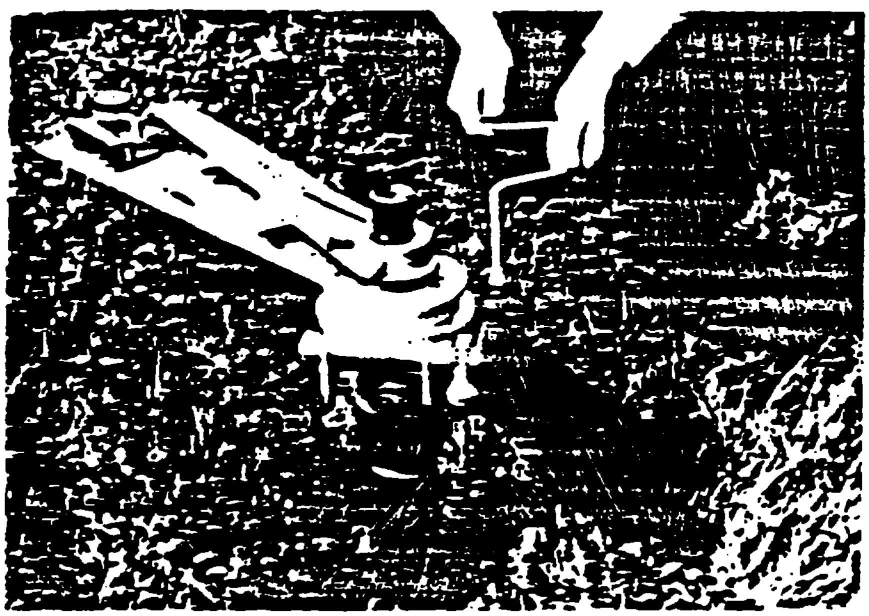


Fig. 89
Precision Vane Shear Torque Head

Dutch Cone Penetrometer

Besides the vane shear test for "on site" testing, there is also : Dutch Cone Penetrometer. The Dutch Cone Penetrometer is used a limited extent in the U. S. but it is used extensively in Europe a a brief discussion of the apparatus and its use would seem to be of vali

While the vane shear test is used primarily in cohesive soils whi can be readily sampled using one of the techniques already discusse the cone penetrometers are most frequently used in cohesionless sc which can not be readily sampled and tested in the lab. Cone penetro eters develop the same kind of information as the standard penetrati test except no sample is obtained. Many feel that the static nature the Dutch Cone Penetrometer provides a more accurate measure of t resistance or density of the soil than the standard penetration te Besides an improvement in the data another advantage is the co penetrometer tends to be somewhat faster so that more information

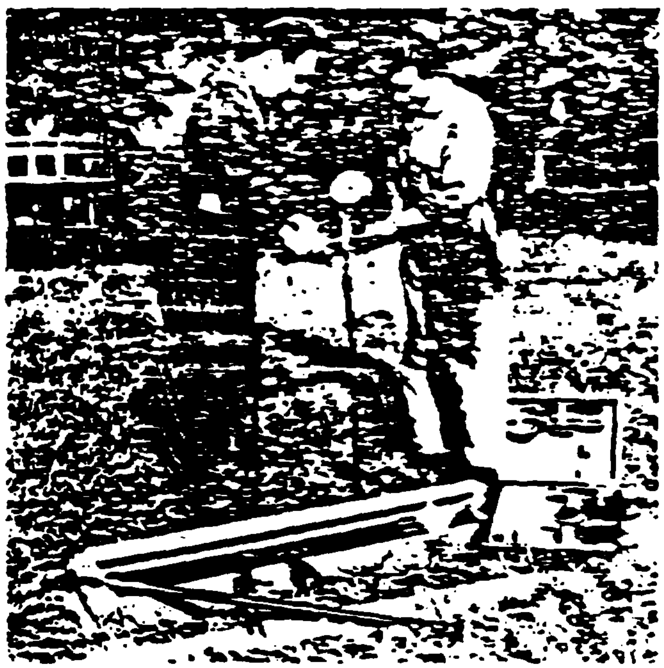


Fig. 98
Hand Operated Dutch Cone Penetrometer

N.V Goudsche Machinefabriek

obtained in the same amount of time. The big disadvantage of this testing procedure is that no sample is obtained during the testing procedures.

The apparatus consists of a concentric set of rods and a cone with a base area of 10 sq. cm. and a point angle of 60 degrees. These are pressed into the soil until the test depth is reached. The force required to drive the rods and cone at this depth is recorded. At this point the outer rods are locked and the inner pressure rods force the cone foreward another 5 cm. The force required to overcome this resistance is read on a pressure guage and recorded. The operation of driving the first tube, and then just the cone is repeated at regular intervals and the results recorded.

There are both hand and mechanically operated machines available. Figure 90 shows the hand apparatus while Figure 91 depicts a larger hydraulically run apparatus.

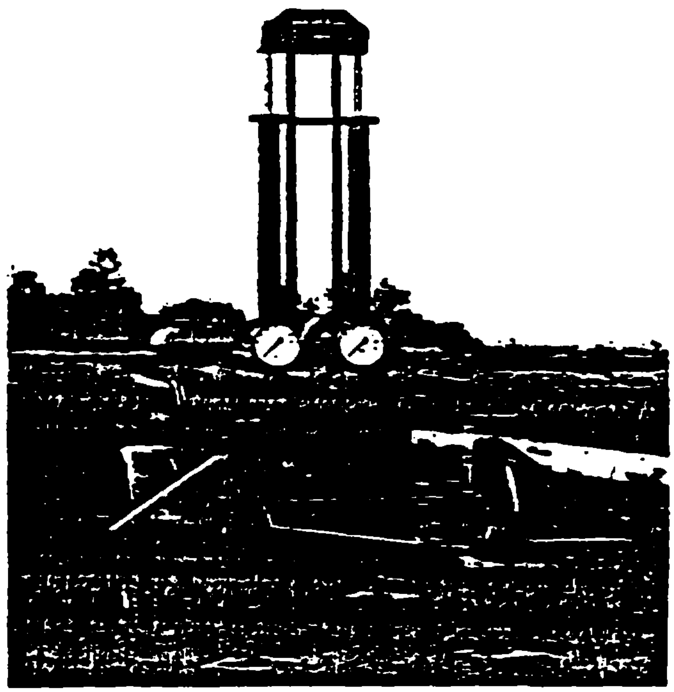


Fig. 91
Hydraulic Operated Dutch Cone Penetrometer

N V. Goudsche Machinefabriek

SAMPLING AND LOGGING LITHOLOGY PENETRATED BY DRILL HOLES

It is usually difficult, if not impossible, to correctly interpret geophysical logs of a test well without additional background knowledge pertaining to the lithologic sequences penetrated in the borehole. We usually obtain this background information by one or more of the following methods: (1) Drillers logs. (2) Geologist log made from the drill cutting returns. (3) Core samples (drive or rotary) taken from the borehole. Core samples are unquestionably the best sample that the geologist can obtain but, they are also the most difficult and expensive to come by. Because of the cost and difficulty of obtaining cores we usually settle for the very poor substitute of drill cuttings from practically any type of drilling performed. However, we are usually concerned with those from either the cable-tool method or, mud-rotary method.

Collecting samples of sands, gravels, and clays when drilling by the cable-tool method is usually a matter of bailing out material as the test hole is deepened. Many drillers prefer to drive casing a relatively short distance, then use the bailer to clean out the plug of material inside the casing after each drive. At other times, the driller may be able to advance the hole several feet into the formation being drilled before it becomes necessary to drive the casing.

If the drilling action causes the casing to continue moving downward, this must be taken into account so that the proper depth measurement for each sample can be noted.

Heaving sand presents a difficult problem in sampling and logging. There is no way to know what part of the sand stratum is represented by the material inside the casing after the heave has taken place. In addition, upward flow of the sand tends to separate the fine sand-fraction from the coarse fraction. The usual practice is to discard the material that moves up into the casing on a heave, and try to obtain a sample from about the same depth as that of the lower end of the casing.

During any drilling and bailing procedure, the fines work toward the top and the coarse particles settle to the bottom of the mass of materia' More than one bailer of material should be mixed together to provide a sample that is reasonably representative of the sampling interval. This is particularly important when sampling sand and gravel formations.

Although sampling by the cable-tool method leaves much to be desired, it is, in my opinion, vastly superior to the mud-rotary method. Collection of representative samples by the conventional rotary method presents severa' difficulties. First, and most important, obtaining representative samples depends considerably upon the skill and the experience of the driller.

Samples of sand or, sand and gravel strata are washed to some extent as they are transported upward from the bottom of the hole by the drilling fluid. Separation of particles of different sizes can be minimized to some extent by proper control of the drilling mud, but it cannot be eliminated entirely. Fine and intermediate sizes of sand are carried upward by the drilling fluid ahead of the coarse particles. These separated particles must be recombined as the material for the sample is collected at the surface.

A common sampling method involves two steps: First, the fluid is circulated while holding up on the bit until all cuttings have been removed from the drill hole. The sampling pit is cleaned out at the same time. Next, the bit is allowed to penetrate the formation for a predetermined distance--say, 2-5 feet. All the cuttings from this interval are then caught as circulation is continued without further drilling.

Rotation of the drill pipe without allowing it to feed downward should be continued while circulating the drilling fluid. This assists in maintaining uniform flow in the annular space around the drill pipe. The mud lifts the cuttings from the sampling interval more readily under these conditions. The cuttings that accumulate in the sampling pit should be removed to a tub or other container and allowed to settle out, the excess drilling fluid should be carefully poured off and the description of the cuttings may then be noted on the well log.

A problem that sometimes arises when test drilling by the rotary method is that material from overlying strata may be eroded from the wall of the hole by the ascending stream of drilling mud and this material will, of course, be mixed with the cuttings from the indicated sample interval. This problem is apt to be more serious in the procedure just described because circulation must be continued for a considerable time after drilling each interval. Drilling successive intervals is also impractical for test holes of considerable depth, since much time is consumed in waiting for each sample.

Because of these situations, it is often necessary to take samples while drilling more or less continuously rather than by using the sample-interval method. The materials caught at the surface while drilling continuously must be combined according to the judgement of the driller or other responsible person collecting the sample. This obviously requires more skill and experience on the part of the person doing the sampling. The time required for transport of the cuttings by the drilling fluid, from the bottom of the hole to the ground surface, must be taken into account in determining the depth represented by the sample. Random collection of cuttings from the mud stream and assigning exact depth intervals to those samples in probably the most abused practice in mud-rotary sampling. If we look at table 2 we can see that the approximate time required to transport a sample up the hole from a given depth can be determined. The problem is, very few people actually bother to keep accurate measurements of mud velocity and travel time.

TABLE 2.--ASCENDING VELOCITY OF MUD

(in feet per minute)

Diameter (inches)		MUD CIRCULATION (GPM)									
Drill Pipe	Hole	100	200	300	400	500	600	700	800	900	1,000
	6	100	200	300							
	6 3/4	73	146	219	292						
3 1/2	7 5/8	55	109	164	219	273	328				
	8 1/2	42	84	125	167	208	250	291	333		
	9 3/8	32	63	95	126	158	189	221	252	284	[illegible]
	7 3/4	63	126	188	251	314					
	8 1/2	48	97	145	193	242	290	338			
4 1/2	9	41	82	124	165	206	248	289	330		
	10 5/8	27	54	80	107	134	161	188	[illegible]	[illegible]	268
	12 1/2	20	40	59	79	98	118	138	158	177	[illegible]
	10 5/8	30	60	90	120	150	180	210	240	270	300
	12 1/4	21	42	63	84	105	126	147	168	189	[illegible]
5 1/2	14 3/4	14	27	41	54	68	81	95	108	122	135
	18	8	17	25	34	42	50	59	67	76	[illegible]
	20	7	13	20	26	33	39	46	52	59	[illegible]

Courtesy J. E. Brantly
"Rotary Drilling Handbook

Uniformity Coefficient

$$\frac{40\%\ \text{Size}}{90\%\ \text{Size}} = \text{UC}$$

The lower the UC value for a sand, the more uniform the grade of sand.

Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

MAILING ADDRESS, P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

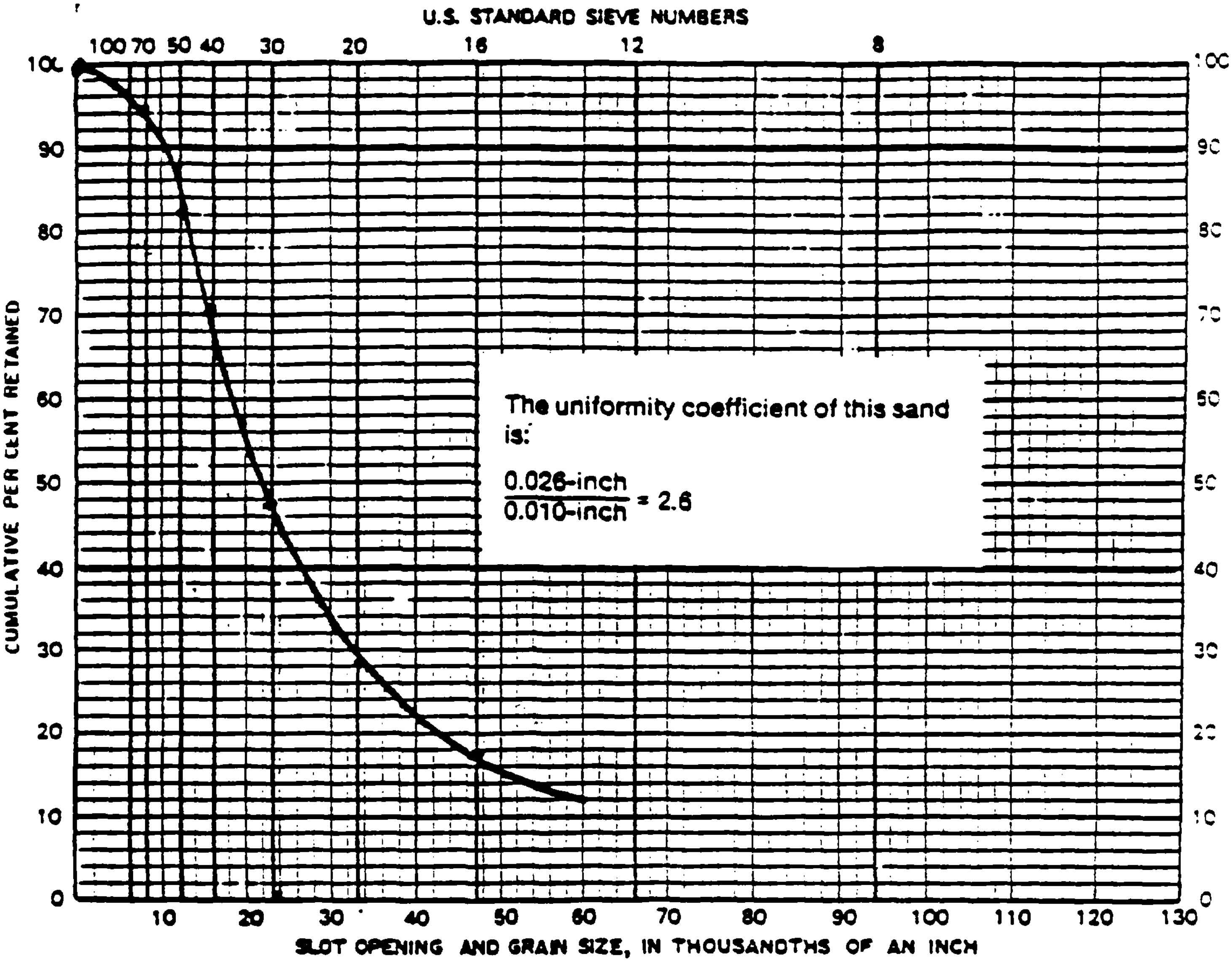
Sample sent in by ______________________________

Town ______________________ State __________ Zip __________ Date __________

From well of ______________________________

Remarks: ______________________________

____



Effective Size

Where 10% is finer and 90% is coarser
(ie: 90% retained size)

Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

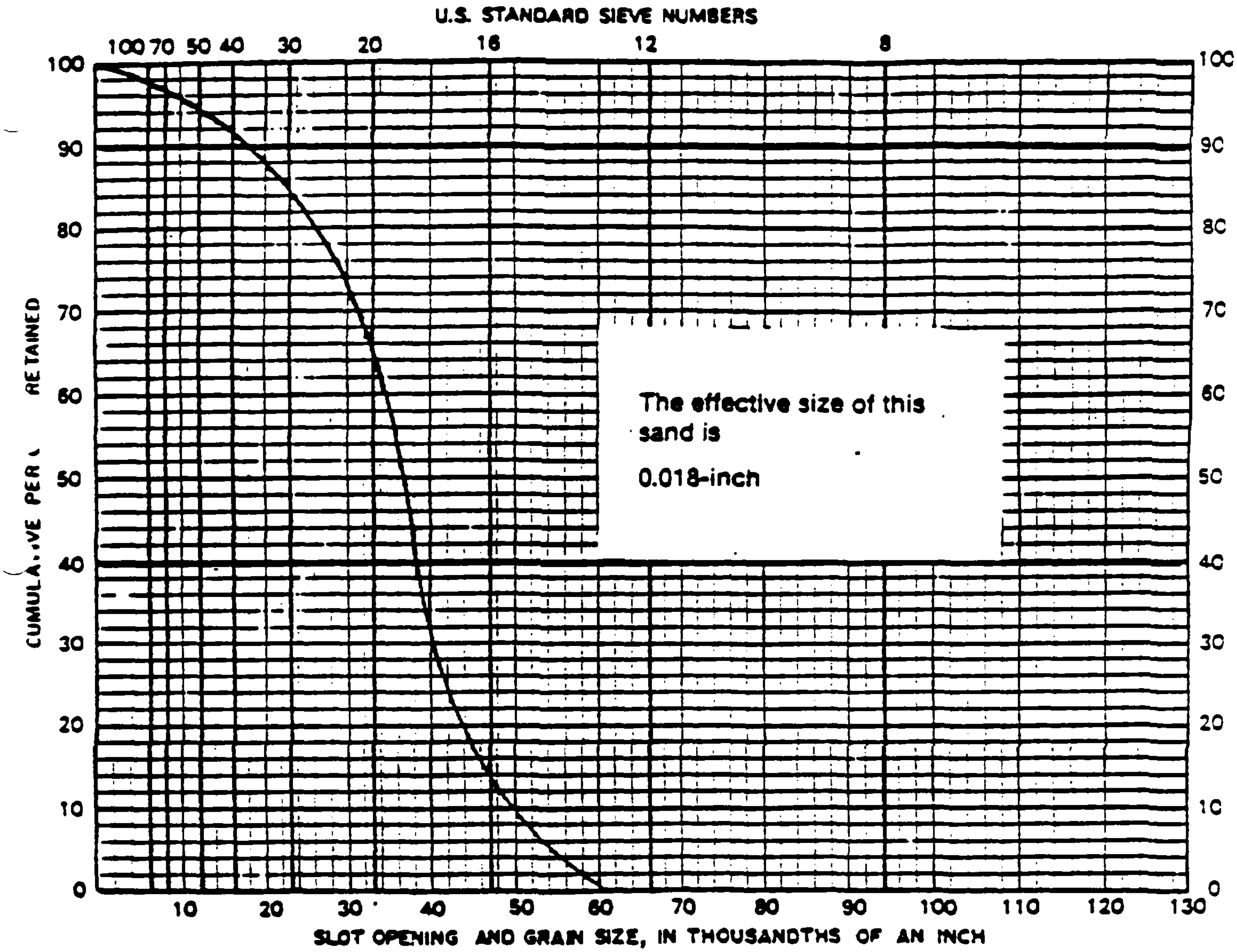
MAILING ADDRESS. P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

Sample sent in by ______

Town ______ State ______ Zip ______ Date ______

From well of ______

Remarks: ______



Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

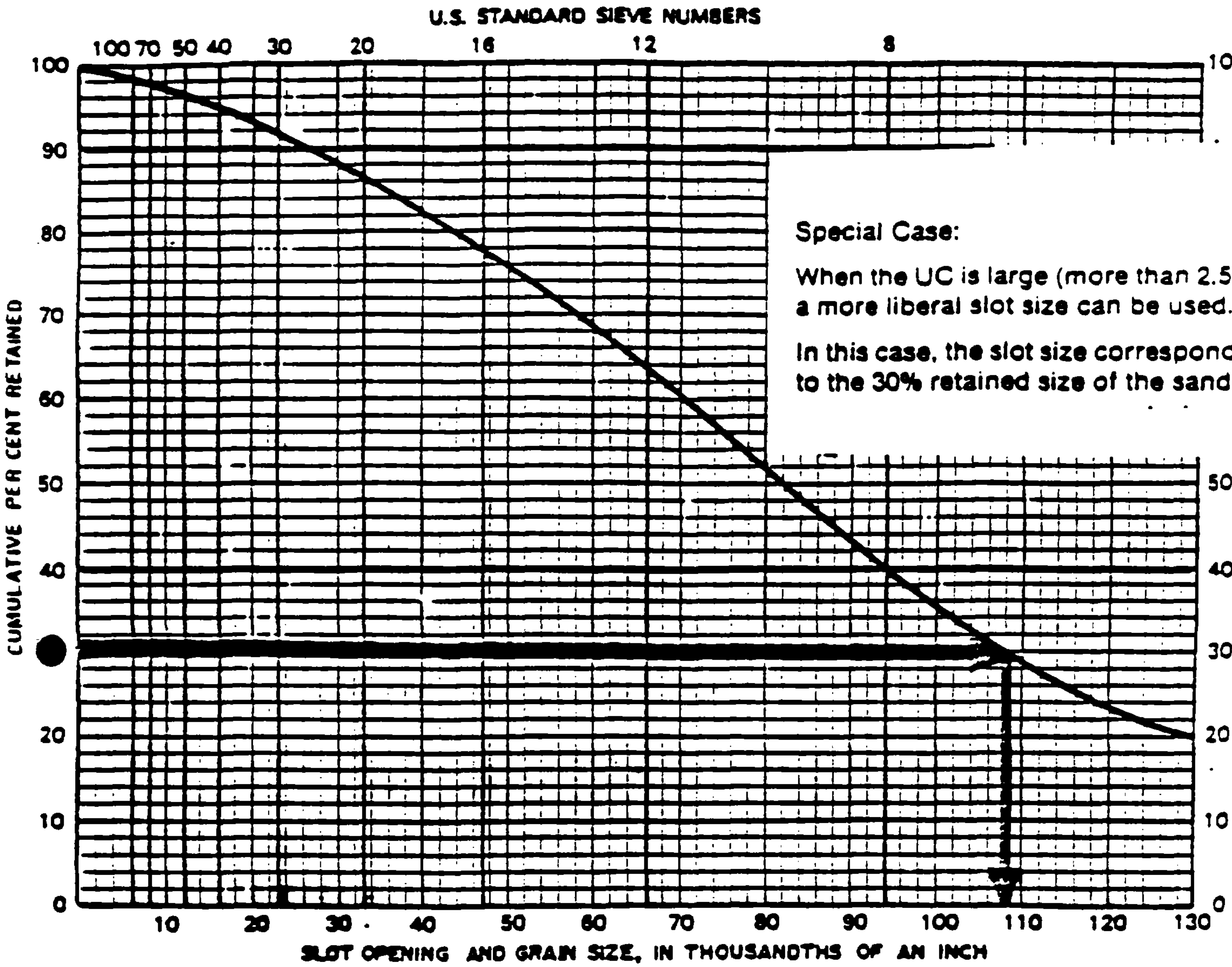
MAILING ADDRESS: P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

Sample sent in by ______________________

Town ______________ State ________ Zip ________ Date ________

From well of ______________________

Remarks: ______________________



Special Case:

When the UC is large (more than 2.5), a more liberal slot size can be used.

In this case, the slot size corresponds to the 30% retained size of the sand.

Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

MAILING ADDRESS: P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

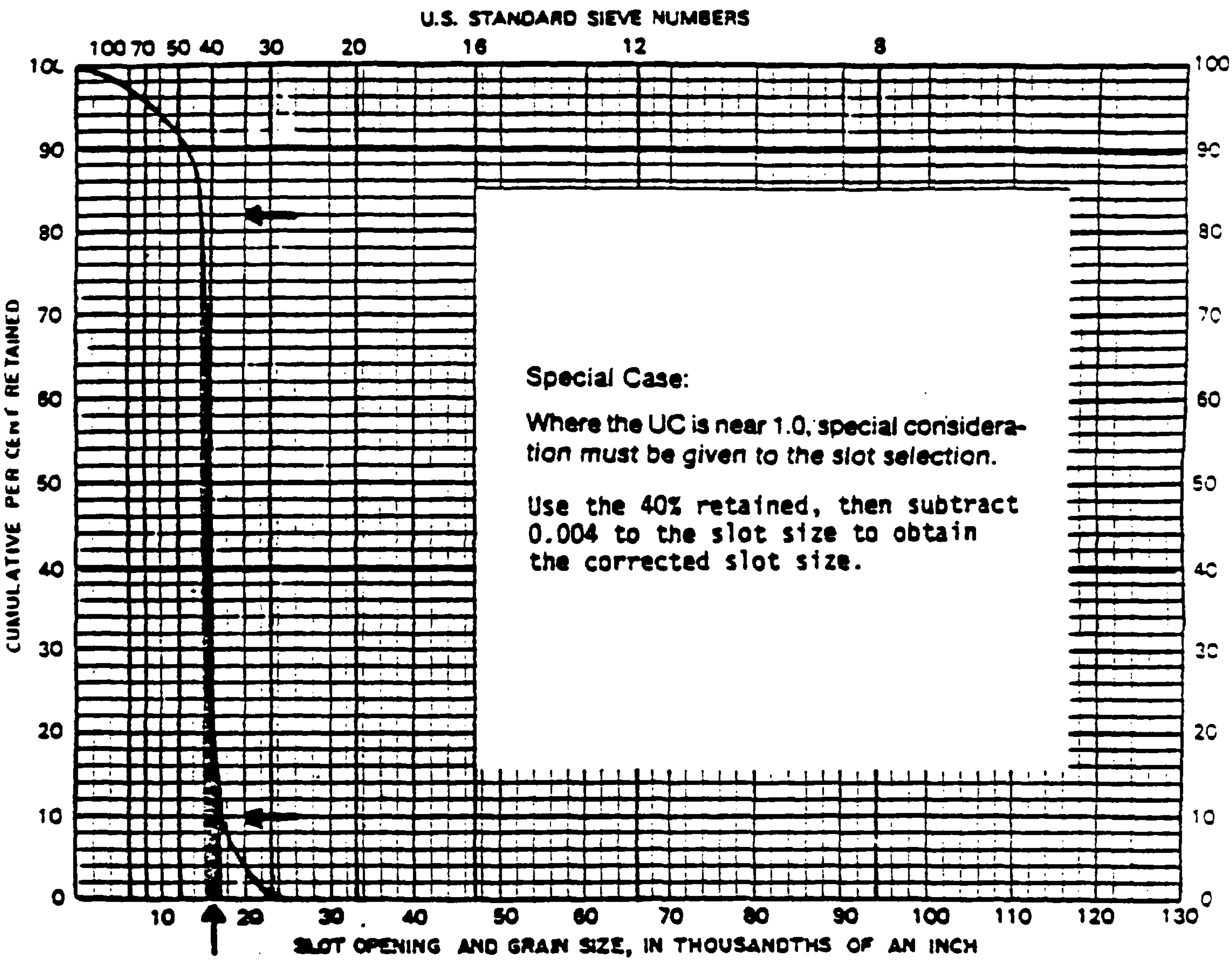
Sample sent in by ______________________

Town ______________ State ________ Zip ________ Date ________

From well of ______________________

Remarks: ______________________

____



Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

MAILING ADDRESS: P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

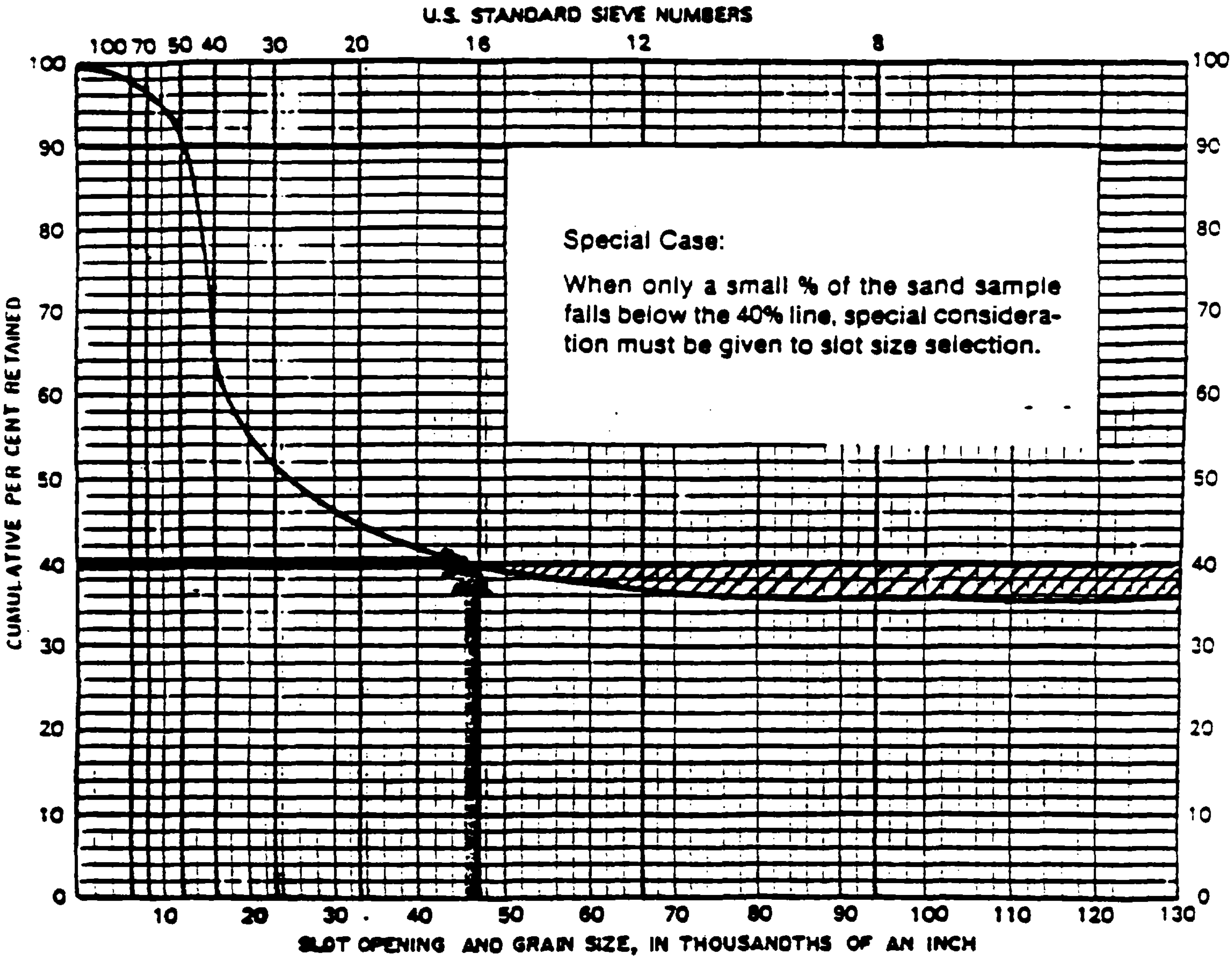
Sample sent in by ______________________________

Town ____________ State ________ Zip ________ Date ________

From well of ______________________________

Remarks: ______________________________

____



Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

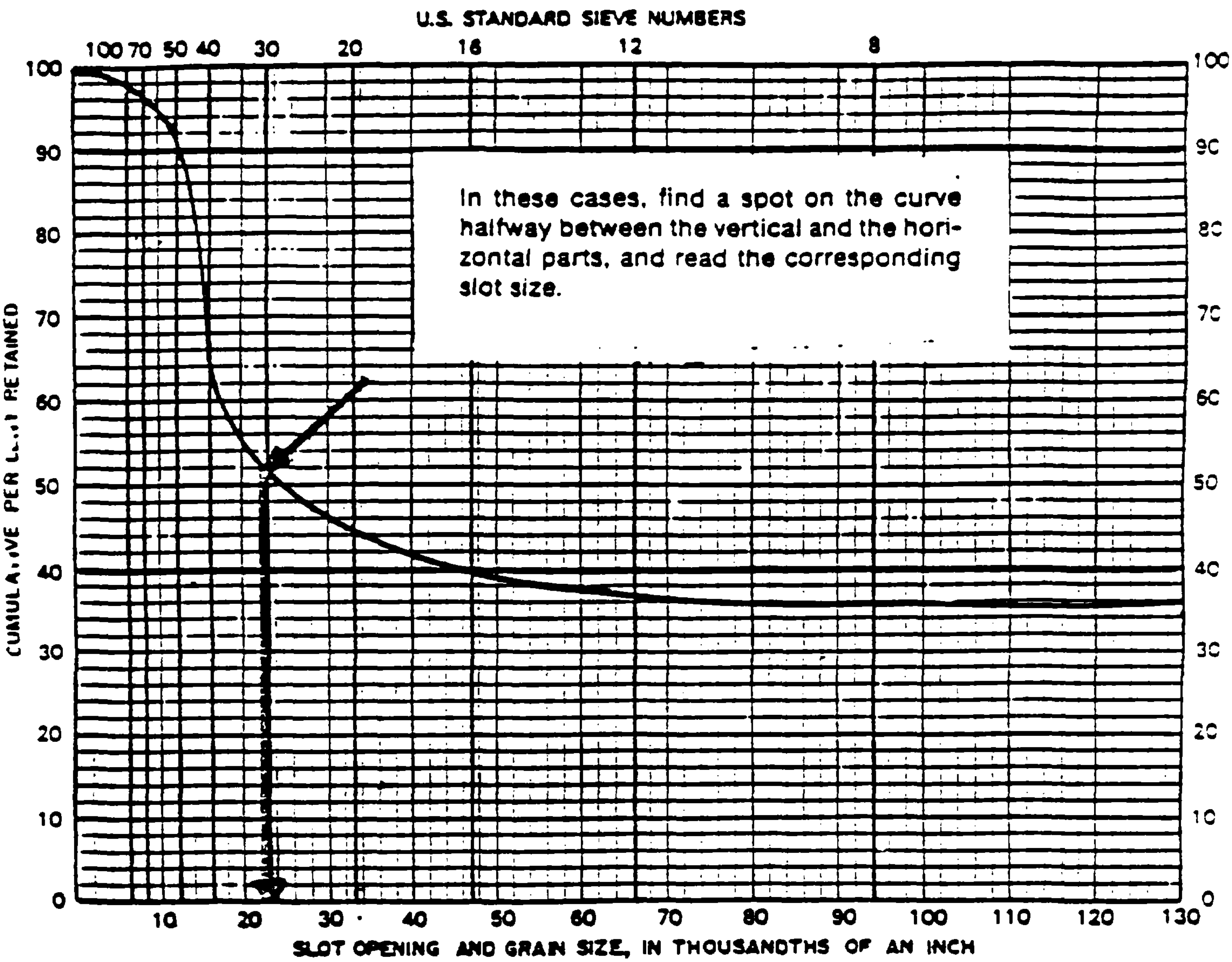
MAILING ADDRESS, P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

Sample sent in by ______________________

Town ______________ State ________ Zip ________ Date ________

From well of ______________________

Remarks: ______________________



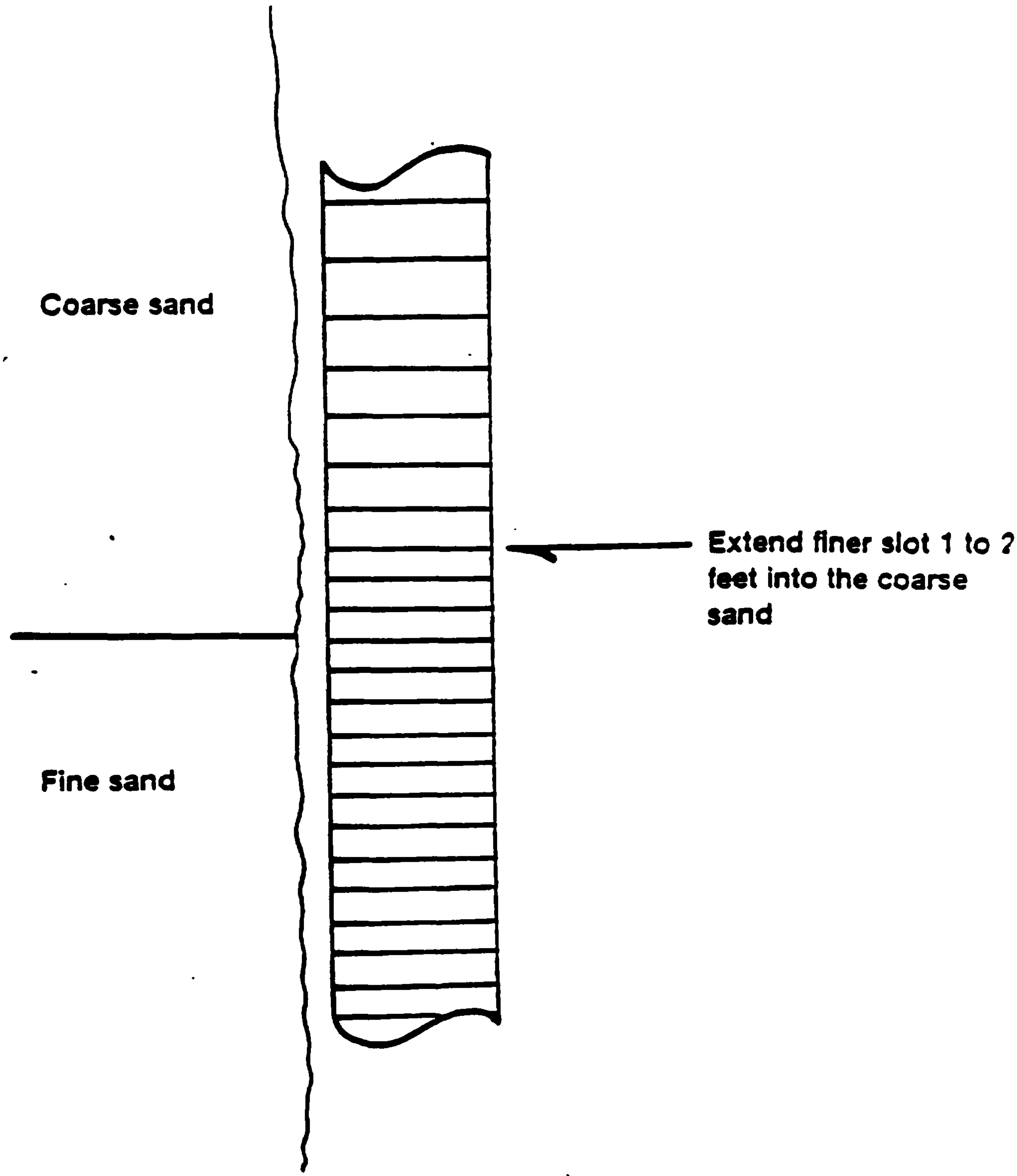
U.S. SIEVE NO.	SIEVE OPENING INCHES	SIEVE OPENING MM	CUMULATIVE % RETAINED		
6	132	3 36			
8	094	2.38			
12	066	1 68			
16	047	1 19			
20	033	0 84			
30	023	0 60			
40	016	0.42			
50	.012	0.30			
70	008	0.21			
100	006	0 15			

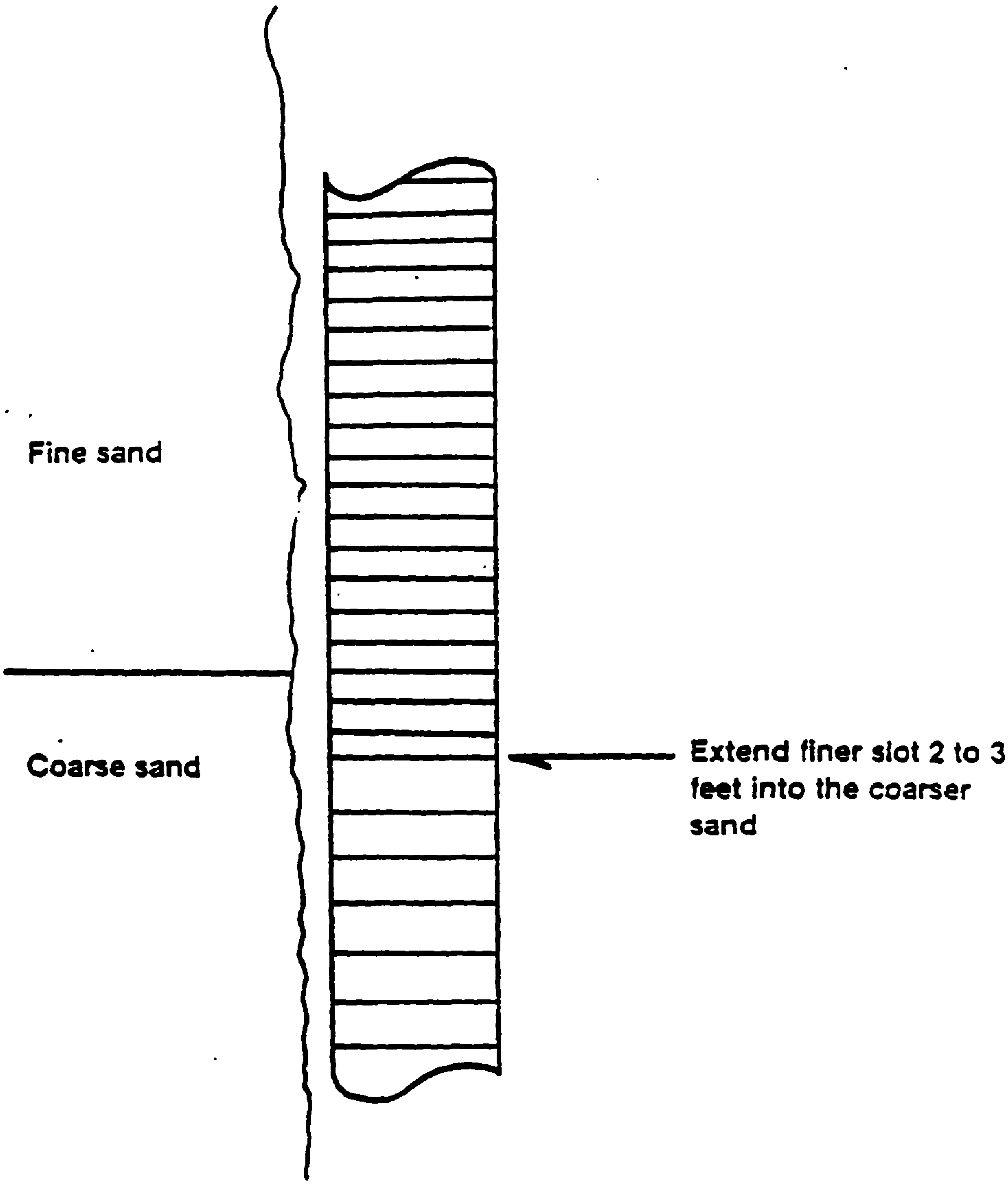
Notes: Stuff in the box

Recommended Slot Opening: 11/13 x 18 M.H.

Recommended Screen: Dia. ________ in. Length ________ Ft.

By: ________


Coarse sand
Fine sand
Extend finer slot 1 to 2 feet into the coarse sand



Fine sand
Coarse sand
Extend finer slot 2 to 3 feet into the coarser sand

When Do You Gravel Pack A Formation?

1. When the aquifer is a fine, uniform sand.
2. When the aquifer is a thick, artesian aquifer.
3. When the aquifer is a poorly cemented sandstone.
4. When the aquifer is highly variable.
5. Almost all reverse circulation drilled holes.

A proper gravel pack is selected from a uniform grade (UC is less than 2.5), clean, well-rounded, quartz sand that is 4 to 6 times larger than the finest aquifer sand.

Use a 4 multiplier when the aquifer sand is fine and uniform (UC = 1 to 1.5).

Use a 6 multiplier when the aquifer sand is medium to coarse and non-uniform (UC = 2.5 or greater).

Johnson Division
P.O. Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc.

SAND ANALYSIS
(FINE)

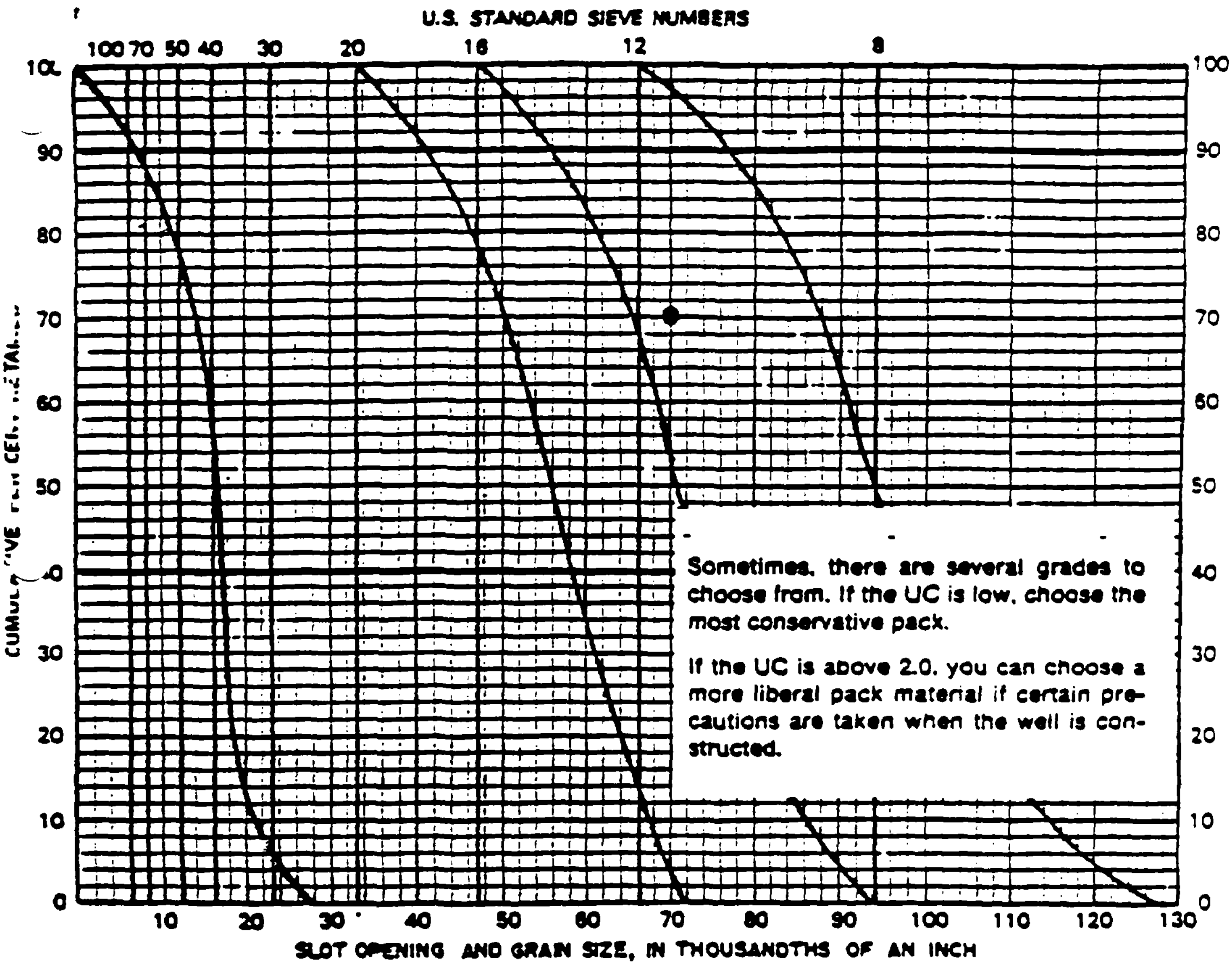
MAILING ADDRESS. P.O. BOX 43118
ST. PAUL, MINNESOTA • 55164

Sample sent in by ______________________________

Town ____________________ State __________ Zip __________ Date __________

From well of ______________________________

Remarks: ______________________________



U.S. SIEVE	SIEVE OPENING		CUMULATIVE % RETAINED		
NO	INCHES	MM			
6	132	3.36			
8	094	2.38			
12	066	1 68			
16	047	1 19			
20	033	0.84			
30	023	0.60			
40	016	0.42			
50	.012	0.30			
70	008	0.21			
100	006	0.15			

Notes: ______________________________

[illegible]

Recommended Slot Opening: [illegible]

Recommended Screen: Dia. __________ in. Length __________ Ft.

__________ By: __________

Johnson Division
P O Box 43118 · St. Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc

SAND ANALYSIS
(FINE)

MAILING ADDRESS P O BOX 43118
ST PAUL MINNESOTA • 55164

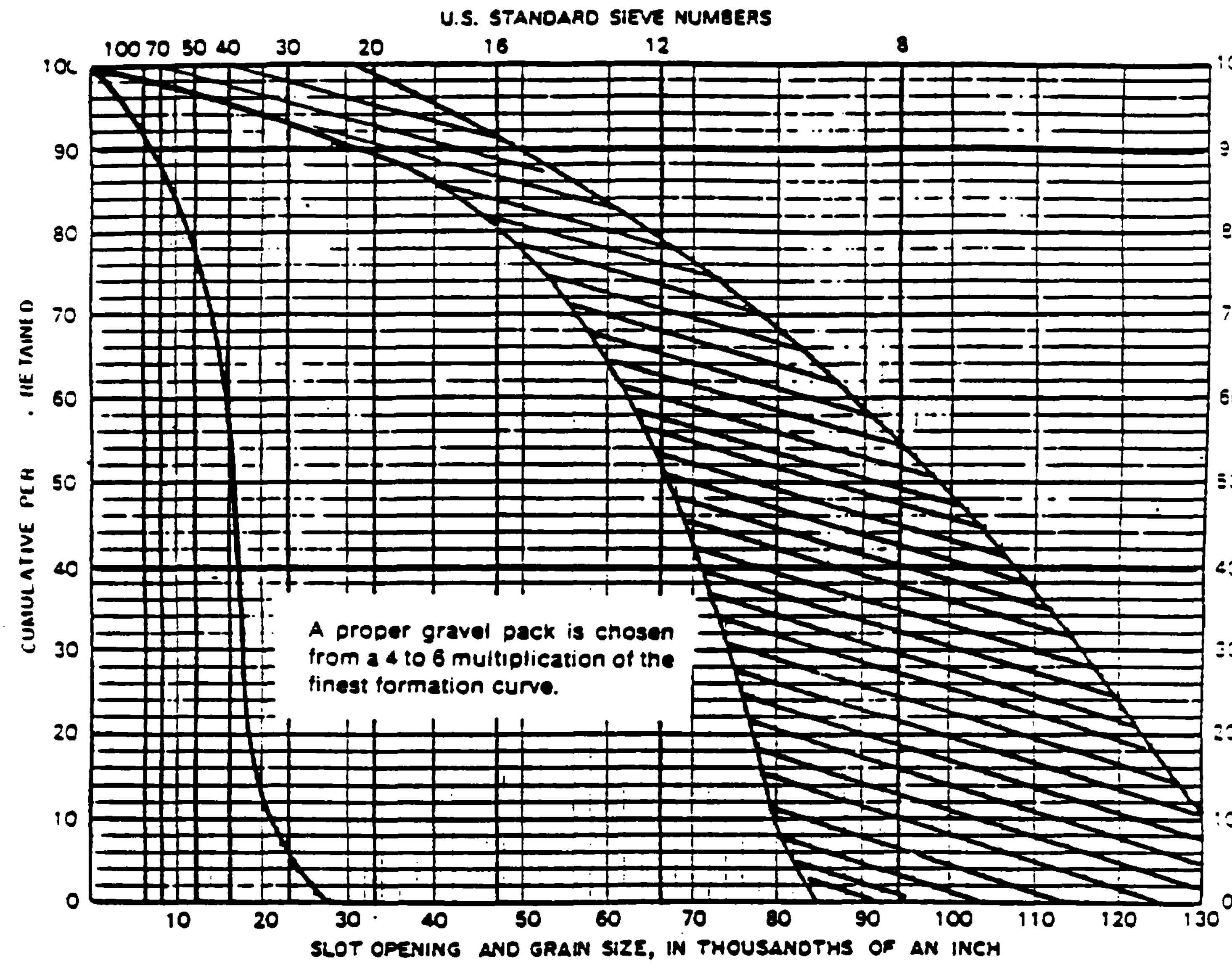
Sample sent in by ____________________

Town ____________________ State ________ Zip ________ Date ________

From well of ____________________

Remarks ____________________

____



Johnson Division
P O Box 43118 · St Paul, Minnesota 55164
Telephone 612-636-3900 · Telex 29-7451
UOP Inc

SAND ANALYSIS
(FINE)

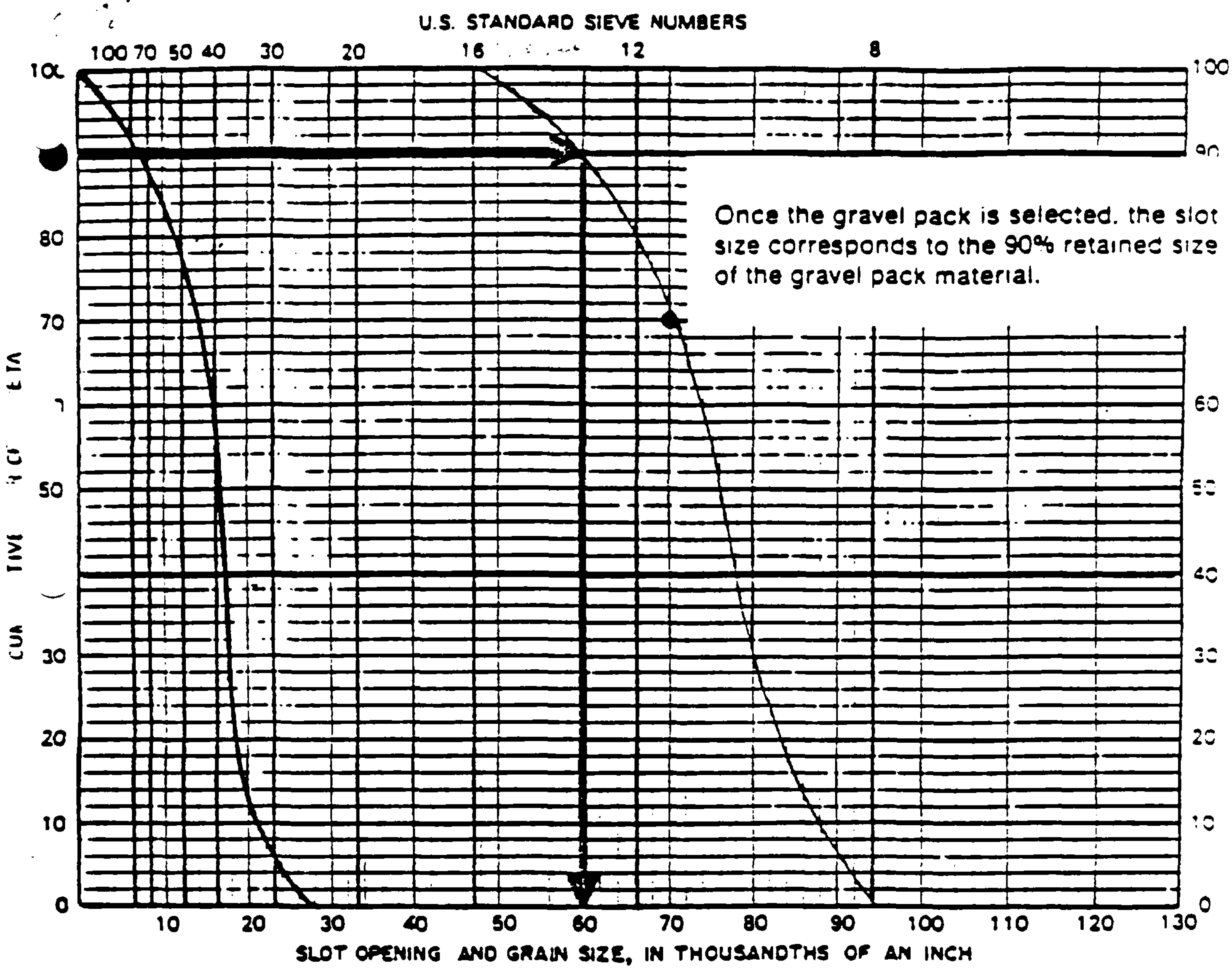
MAILING ADDRESS P O BOX 43118
ST PAUL MINNESOTA • 55164

Sample sent in by ______________________

Town ______________ State ________ Zip ________ Date ________

From well of ______________________

Remarks ______________________



SIEVE NO.	SIEVE OPENING INCHES	MM	CUMULATIVE % RETAINED		
6	132	3.36			
8	094	2.38			
12	066	1.68			
16	047	1.19			
0	033	0.84			
30	023	0.60			
40	016	0.42			
50	012	0.30			
70	008	0.21			
100	006	0.15			

Notes. ______________________

Recommended Slot Opening ______________________

Recommended Screen: Dia. ________ in. Length ________ Ft.

______________________ By: ________

Reference for Sand Analysis

U.S. Department of Interior, "Ground Water Manual", 1977

Hazen, Allen, "Some Physical Properties of Sands and Gravels", Massachusetts State Board of Health, 24th Annual Report, 1893

Johnson Screens, "Groundwater and Wells", Johnson Screens; St. Paul, Minnesota, 1975

Suman, George O., Sand Control Handbook, Word Oil; Houston, Texas, 1975

MONITORING WELL DEVELOPMENT

Tyler E. Gass
Blasland & Bouck Engineers, P.C.
Syracuse, New York

Upon completion, all wells require development. Well development is required to correct damage done to the borehole during drilling, remove clay, silt or fine sand from the formation adjacent to the well screen to minimize or eliminate the pumping of fine particles, and to stabilize the borehole. Unfortunately, because of their design and intended use, ground-water quality monitoring wells are difficult to properly develop. This month's column will address these difficulties and describe appropriate procedures for monitoring well development.

Borehole Damage

All drilling methods impair the ability of an aquifer to transmit water to a drilled hole. The impairment may be due to the physical rearrangement of the matrix of the aquifer material, or to formation damage as a result of the invasion of drilling fluids or solids into the aquifer, causing reduced permeability adjacent to the borehole. Regardless of cause, the damage to the borehole must be corrected, if well evacuation and sampling of the monitoring well are to be successfully performed.

Problems Associated With Monitoring Well Development

Well design and the use of the wells for water quality sampling place restrictions on the types of well development methods appropriate for ground-water quality monitoring wells. Because of the low rates at which ground water is extracted from a monitoring well, the typical monitoring well will have a short screen, often machine slotted, with slots ranging from .006

to .020 inches in diameter. Although the total open area of the well screen is small, in most cases there is enough open area to keep entrance velocities low enough during sampling to avoid degassing and/or alteration of ground-water quality. Unfortunately, the narrow slots, and limited open area, combined with well diameters as small as 1½ inches, makes well development extremely difficult. The limited open area makes correction of borehole damage difficult, and adequate removal of fines in the adjacent formation is all but impossible. Wells having a diameter of two inches or less cannot be overpumped or rawhided, and other surging techniques are of limited effectiveness. If the well has a sand pack, then the ability to correct borehole damage is further restricted, although if properly designed, the sand pack should prohibit the migration of fine particles into the well during sampling.

A larger diameter well four inches or larger, with a wire wound screen and a naturally developed filter pack, will provide good conditions for well development. Unfortunately, the high cost of some well construction materials has resulted in the proliferation of two-inch wells with machine slotted casing for screens. In addition, some State and Federal regulations appear to encourage the use of sand packs for most monitoring wells.

An arsenal of various chemicals has been developed to facilitate the development of water supply wells. These chemicals include - acids, surfactants, chelating agents, wetting agents and disinfectants. Unfortunately, these chemicals can migrate into the formation and may affect the quality of ground water in the vicinity of the well. As a result, chemicals are not generally used for development of a ground-water quality monitoring well.

Most ground-water quality monitoring wells have been designed for low capacity pumping. Typically, the well diameter is so small that standard well development tools are impractical, and if things were not bad enough, chemicals that would facilitate well development are prohibited.

Methods of Well Development

In spite of all the restrictions, we must still develop quality ground-water monitoring wells. In areas where the formations consist of clean sands or gravel, development will be relatively easy, but where the well has been completed in a silty-fine sand, some glacial tills or formations considered to be aquitards then development of a two-inch well is going to be a nightmare. Nonetheless, we do have some options available that may allow the contractor and consultant to sleep easier at night. These options (or methods) involve mechanical well development. Factors such as well design and hydrogeologic conditions will determine which development methods will be most practical and cost-effective. Several methods of well development and their advantages and disadvantages are described below.

1. Overpumping involves pumping the well at a rate substantially higher than the rate it will be pumped during well evacuation and ground-water sampling. The intent is to pump the well at the highest rate attainable, increasing the drawdown in the well to the lowest permissible level. This results in increased flow velocities that induce the flow of silt, clay and other debris into the well, opening screen slots and pore spaces, and/or cleaning fractures.

For effective overpumping, it is usually necessary to pump the discharge to waste. This can be a problem where ground water extracted during well development may be contaminated by hazardous waste or hazardous waste constituents.

Overpumping works best in relatively clean, coarse formations and in some consolidated rock aquifers. Perhaps its most significant advantage lies in its simplicity.

Its disadvantages include - problems associated with the disposal of discharge water; bridging of particles against the well screen; the inability to pump most two-inch wells at a rate high enough to permit effective development; and the fact that the technique is relatively ineffective in poorly sorted and dirty formations.

2. Rawhiding overcomes the bridging that results from overpumping by allowing the water that is pumped to the top of the well to flow back through the pump and out through the intake portion of the well. The back flushing breaks up the bridged particles, allowing them to be subsequently pumped from the formation and removed from the well. This method has the advantages of low cost and simplicity. However, it has the disadvantage of preferentially developing the most permeable zones of the formation surrounding the intake portion of the well.

3. Surging, even in small diameter wells can be a very effective means of monitoring well development. A surge block (Figure 1) is attached to drill rod or drill stem, of sufficient weight to cause the surge block to drop rapidly on the downstroke, forcing water contained in the borehole into the

aquifer surrounding the well. In the recovery stroke or upstroke, water is lifted by the surge block, allowing the flow of water and fine sediments back into the well from the aquifer.

Drilling contractors frequently fabricate their own surge blocks for wells of specific diameters. However, this is rarely done for wells smaller than four inches. As a result, we have designed and constructed our own surge blocks designed to fit wells with inside diameters of 1½ inches or larger.

The surge block is schematically represented in Figure 2. The rubber belting should be cut to fit snuggly within the inside of the casing. Metal washers placed above and below the belting will help keep the belting rigid. A pair of hexagonel nuts are used to sandwich the washers and belting material together tightly.

For screens five feet in length or less, surging above the screened interval is very effective for development of the full length of the screen. However, for screen lengths longer than five, especially where the formation adjacent to the screen is variable, there exists the potential for preferential development of either the upper 25 percent of the screen or the most permeable zones adjacent to the screen.

For screens longer than five feet, surging within the screened interval may be performed, but only after taking precautions to avoid sand locking the surge block in the screen or causing damage to the screen. Surging within the screen can be successfully accomplished by cutting down the diameter of the belting material so that it is from ¼ to ½ inch smaller than the inside diameter of the screen. The reduction in size serves two functions. First, it reduces both the positive and negative pressures exerted on the casing and screen by allowing some water to flow past the surge block on the up and downstrokes. Second, it allows fine sediment to flow around the belting rather than lodging between the belting and the screen. When surging within the screen, slow short strokes are used directly opposite the zone you wish to develop. A three foot stroke is adequate. The surge block is then raised or lowered to initiate development in the next part of the screen.

Periodically, the surging should be stopped and the well should be bailed or sand pumped to remove sediment and debris that may accumulate near the bottom of the screen. Since it may be difficult to remove all the sediment that may accumulate in the well during development (and in some cases during subsequent sampling) we often attach a one to five foot length of casing to the bottom of the screen in which to allow sediment to accumulate.

4. Jetting has been used satisfactorily for developing wells in unconsolidated and consolidated formations. Water jetting can open fractures and remove drilling mud that has penetrated the aquifer. A typical jetting tool is illustrated in Figure 3.

The discharge force of the jetting tool is concentrated over a small area of the well screen. As a result, the tool must be rotated constantly while it is raised and lowered in very small increments to be certain that all portions of the treated zone are exposed to the jetting action.

Like a surge block, the jetting nozzles should fit close to the inside of the screen or the borehole face because the veclocity of the jet stream is dissipated within a few inches. Like a surge block, jetting tools can be readily fabricated to fit into wells with diameters as small as 1½-inch.

Perhaps the only significant disadvantage to the use of jetting is the fact that an external supply of water is necessary. The quality of this water should be determined prior to its use to ensure that it will have no long-term effects on the integrity of ground-water samples.

The jetting method has several advantages. The equipment is simple to use and readily available, and the technique is easy to apply. The jetting energy can be concentrated to perform development where it is most needed. By pumping, or air lifting during the jetting process, the fine, dislodged materials are drawn back into the well and pumped out.

5. Air Surging is perhaps the most widely used method of developing small diameter monitoring wells. The attractiveness of air surging lies in the fact that it is simple and easy to perform and "appears" to work. While it may be an extremely effective method of cleaning debris from the well, it has very little positive affect beyond the well screen. To some extent, blowing air out into the well may cause air to become entrained in the narrow slots of the screen and/or the pores of the formation immediately adjacent to the borehole. This creates two problems: the entrained air which is difficult to remove reduces formation permeability and the percent of open area of the well screen; and the entrained air may affect ground-water quality during sampling.

If possible, air surging should be avoided and replaced by air lift pumping. Figure 4 illustrates the critical components of a typical air-lift system. This is a two-pipe system, where an air injection pipe is installed inside a discharge or eductor pipe. Air is injected through the inner pipe at sufficient pressure to bubble out into the surrounding eductor pipe. The bubble, thus formed, reduces the unit weight of water in the eductor pipe causing this column of water to be lifted upward and allowing water from outside the well to rush into the well. Note that all air discharged into the well should be filtered to remove compressor lubricant.

Other methods of well development are also available. For example, a bailer can be used in much the same fashion as a surge block in small diameter wells. Or a well can be backwashed by adding water to it to agitate and remove fines plugging the screen and formation. Of course there are a whole list of variations that can be applied to the methods discussed to achieve results for different well designs and hydrogeologic conditions.

Regardless of the method of well development selected, there are a few points that are universally applicable. First, well development should be initiated gently. As flow is established through the intake portion of the well, then the degree of agitation can be slowly increased. Secondly, do not try to place a time limit on development, such as an hour or two. The well should be developed to a point that water can flow as readily into the well as aquifer conditions will permit. The flow should also be reasonable clear and free of sediment. Thirdly, if one method does not work, try another or use a combination of methods. Do not be afraid to experiment and do not give up too hastily.

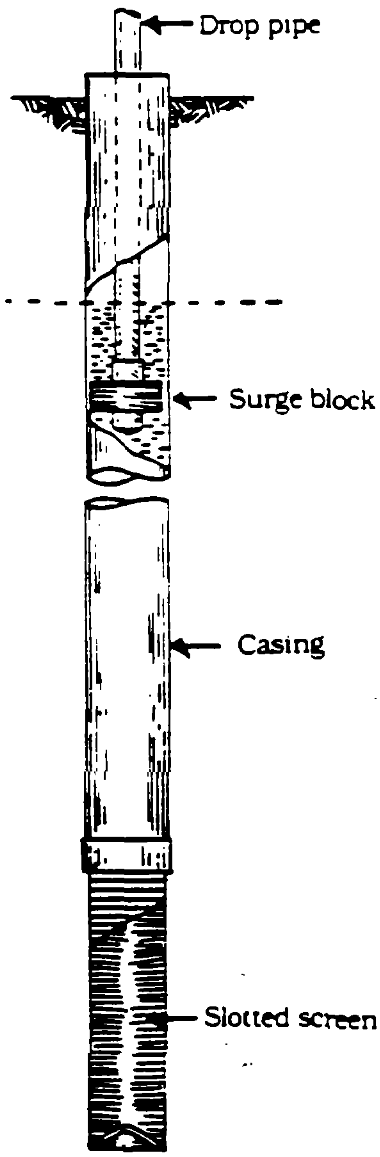
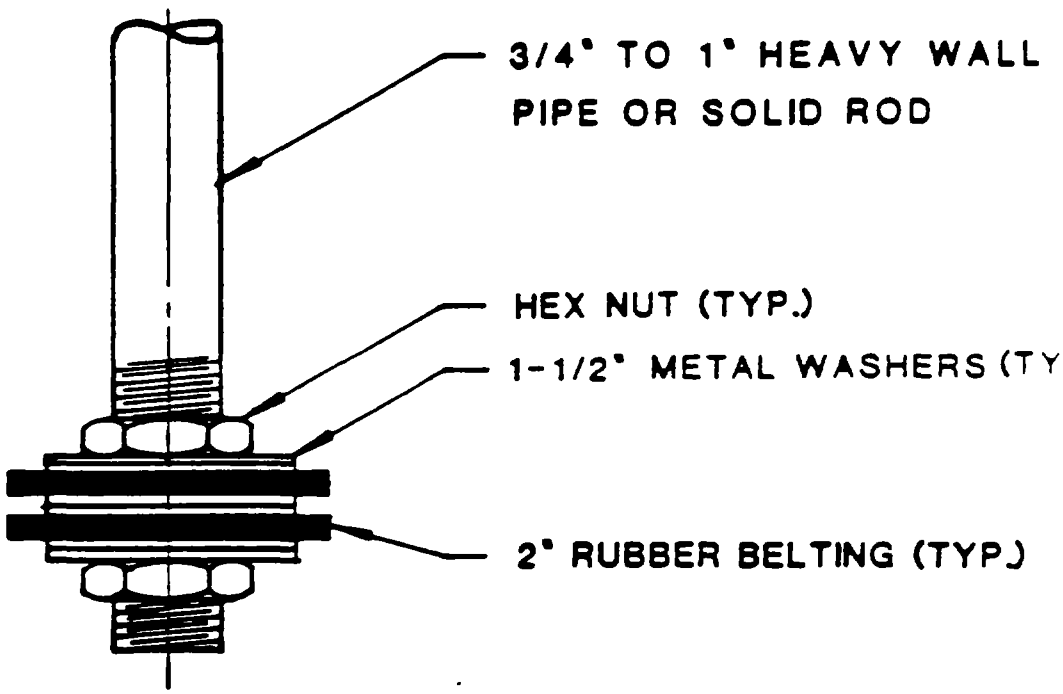


FIGURE 1. DEVELOPMENT WITH A SURGE BLOCK



TYPICAL DESIGN OF A SURGE BLOCK
FOR A 2-INCH I.D. MONITORING WELL

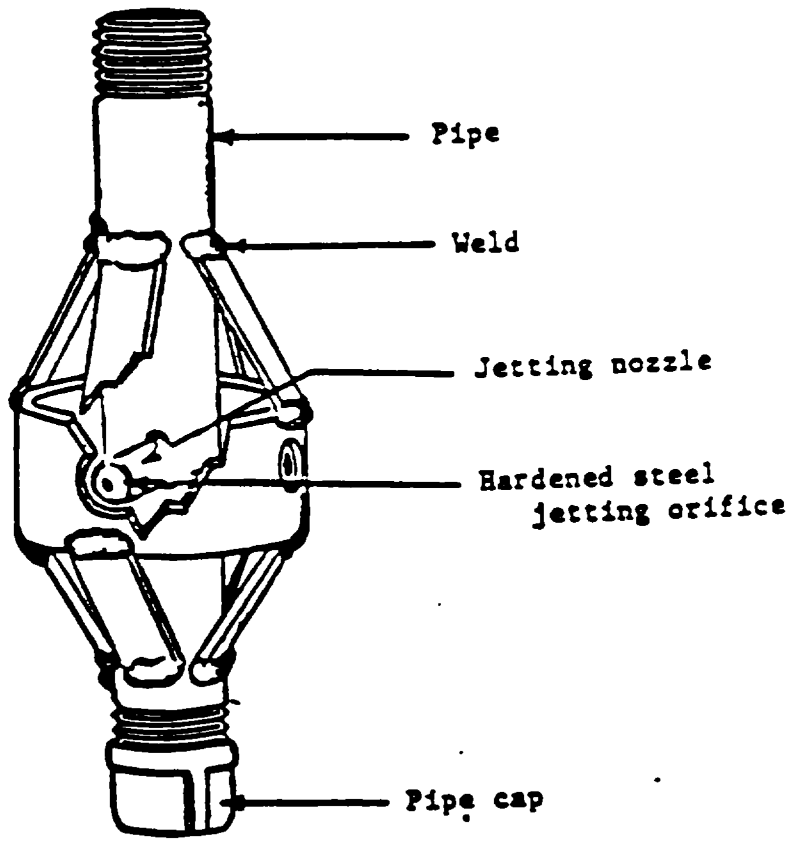


Figure 3. - Diagram showing a simple type, four nozzle jetting tool.

DEVELOPING AND COMPLETING OBSERVATION WELLS

As we are called on to install more observation wells, often under conditions less than ideal for completion, it would seem that many of us could benefit from a discussion of some of the methods available for developing observation wells so that they will readily respond to water-level fluctuations. The methods that are included here are a combination of methods that I have used, that other equipment unit personnel have experimented with and found successful, and some methods are from available well-industry literature.. None of these methods is a guarantee of success and sometimes, any amount of development work will not make an observation well successful.

In providing these data on well development, I do not wish to imply that they are the only methods available. I believe that any of us that have worked in the fields of well drilling and well completion for any length of time realize that the axiom, "necessity is the mother of invention," has never had a better home than in this business. At least, it seems to me that, whenever I get into downhole trouble or problems, I can never open a book and find a ready solution to that problem. In fact, you can seldom find another individual in your field that has had or solved the exact problem that you are faced with. Well development, like all other drilling problems, will pose difficulties that require individual initiative and inventiveness to solve. So, the following discussion concerning well development is intended as an aid—not the total answer.

Surging With Air

Surging and pumping by air is probably the best all-around methc for development and, in wells of small diameter (2 inches or less), : about the only way of development. Much of the following data on sur with air is from Edward E. Johnson, Inc., "Ground Water and Wells," : edition, 1966.

Compressed air may be used effectively as a development tool. ⟩ drillers do all of their development work with air. To do the job, : air lift, with the air pipe inside an eductor or pumping pipe, is installed in the well.

The equipment needed for this method includes the following:

1. Air compressor and tank of required size.
2. Pumping pipe and air line in the well, with means for raising and lowering each independently of the other.
3. Flexible high-pressure air hose to permit raising and lowering the air line in the well.
4. Pressure gauge and relief valve to safeguard against accidental overloading.
5. Quick-opening valve in the outlet of the tank for controlling air flow.

The compressor should be capable of developing a maximum press of not less than 100 pounds per square inch (psi). A rough but use rule of thumb for determining the proper compressor capacity, in cu feet per minute (cfm), is to provide about three-fourths of a cubic of free air for each gallon of water at the anticipated pumping rat

The outlet of the compressor should be connected to the air tank in a way which will minimize resistance to the air flow. The outlet pipe leading from the tank to the well should be as large as, or larger than, the air line in the well. The quick-opening valve should be connected at a convenient point. A high-pressure hose connects from the outlet pipe of the tank to the air line in the well. This hose should be at least 15 feet long to allow for moving the air-lift assembly up and down in the well.

Figure 1 illustrates the proper method of placing the pumping or eductor pipe and air line in the well. The pumping pipe is handled with the sandline or other hoisting means, and the air pipe can be handled with the cathead or another winch. A tee at the top of the pumping pipe is fitted with a discharge pipe at the side outlet. A bushing with inside opening large enough to clear the couplings of the air line is screwed to the top of the tee. Wrapping burlap or similar material around the air line just above the tee reduces spraying about the top of the well.

Air development produces best results when the submergence ratio of the air line is about 60 percent. This is the proportion of the total length of air line that is below water while pumping.

To calculate submergence, the length of air line under water is divided by the total length of air line. If, for example, the air line is 180 feet long and the static water level is 61 feet below ground, the submerged length is 119 feet. The non-pumping submergence ratio is:

$$\frac{119}{180} = 0.66 \text{ or, } 66 \text{ percent}$$

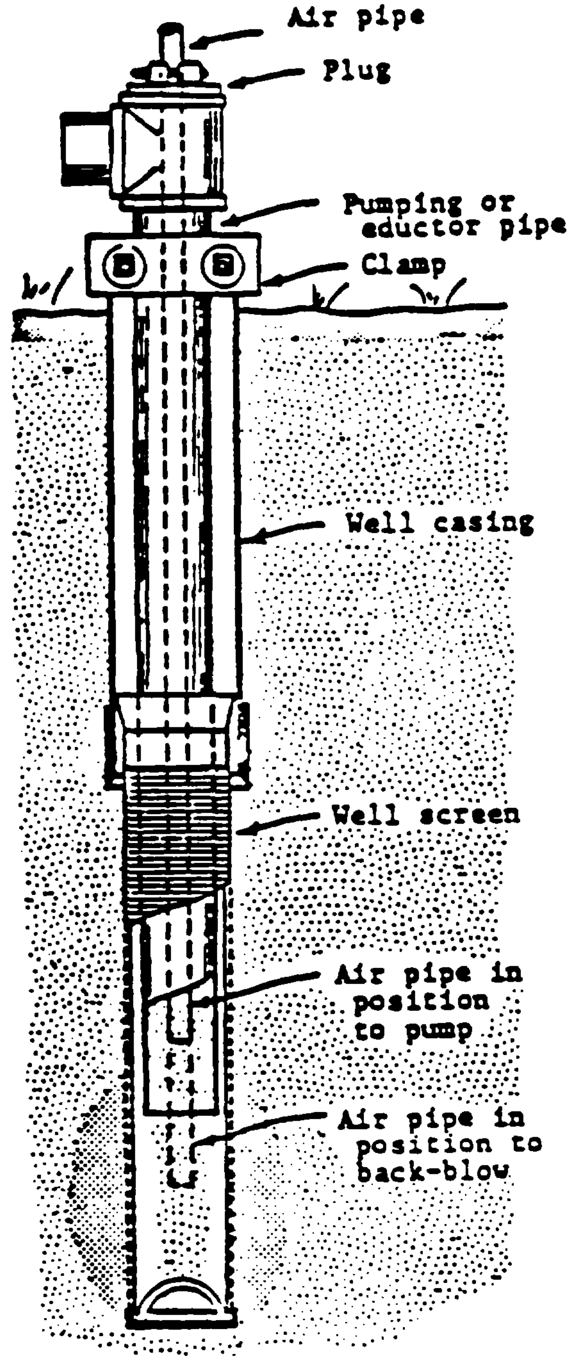


Figure 1. - Diagram of a well showing equipment installation for well development using modified air-lift method.

If the air lift is started and the water level drops to 74 feet, the submerged length becomes 106 feet and the submergence ratio, while pumping, is:

$$\frac{106}{180} = 0.59 \text{ or, } 59 \text{ percent}$$

Reasonably good results can be obtained by a skillful operator with submergence as low as 30 percent while pumping.

Before blowing any water or drilling mud out of the well with a sudden injection of air, the air lift should be operated to pump water slowly from the well. This is done to make sure that some water is entering the well from the aquifer, so that excessive differential pressure will not occur when large volumes of air, under high pressure, are released inside the well screen during the surging operation. This is particularly dangerous when working with plastic pipes or screens as they are easily damaged. For more information, see later section on air development of small-diameter wells. For pumping alone, the air line needs to be lowered only far enough to have good submergence.

When starting development, the pumping pipe is lowered within about 2 feet of the bottom of the screen. Air is turned into the air line and the well is pumped in the manner of a conventional air lift until the water appears to be free from sand. The valve at the outlet of the tank is then closed, allowing the pressure in the tank to build up to 100 psi. In the meantime, the air line is dropped so that its lower end is a foot or so below the discharge pipe. The valve is then quickly opened to allow air from the tank to rush suddenly into the well. This tends to surge the water outward through the well-screen openings. Ordinarily, a brief but forceful head of water will overflow or shoot from the casing and from the pumping pipe at the surface. If the air line is pulled up into the pumping pipe after the first charge of air has been released into the well, the air lift will again pump, reversing the flow, and completing the surging cycle.

The well is pumped as an air lift for a short time, then another "head" of air is released with the drop pipe below the pumping pipe and the air line is again lifted to resume pumping. Surging cycles are repeated until the water is relatively free of sand or other fine particles. This indicates that the development is approaching completion in the region near the bottom of the air lift.

The air-lift assembly is then raised to a position a few feet higher in the well and the same operations are repeated. In this way, the entire length of the screen is developed a few feet at a time.

The operator doing this type of development work varies the procedure in detail so that the surging and pumping is done to best advantage in each well. There is no fixed routine which can be substituted for the driller's skill acquired from practical experience.

Air Surging Small-Diameter Wells

A more difficult type of well to develop by the air-surging method, and also the type that we are more apt to be involved with, is the small-diameter observation well of 2-inch diameter or less.

It is almost impossible to use the standard air-lift method, where we use an eductor pipe and air-line pipe inside the casing, if that casing is 2-inch or less diameter. As an example: If we have a 2-inch casing, we would not be able to install anything larger than 1-inch pipe for the eductor and a 1/4-inch pipe for the air line. These size restrictions would not allow us enough air volume or velocity to perform any successful development work inside the well screen or perforated zones if we used the standard air-lift method.

There is, however, a method of air pumping or surging that will usually result in successful development of small-diameter wells. This method differs from the standard air lift, in that no eductor or pump pipe is used. You simply run an air line to the bottom of the hole and use the casing as the pump pipe, as illustrated in figure 2.

What you want to accomplish is a near-instantaneous release of air that will simultaneously push the column of water out of the well and blast the screen and formation to dislodge and move fine particles. As soon as the discharge of water at the surface has dissipated, you should immediately turn the air supply off so that water can reenter the well. As soon as several feet (hopefully 25-50 ft.) of water have reentered the hole, the surge-blast action is repeated. This operation should be repeated for as long as you are still getting fines and muddy water from the well. Once the discharged water becomes clean, you usually will not accomplish any additional development.

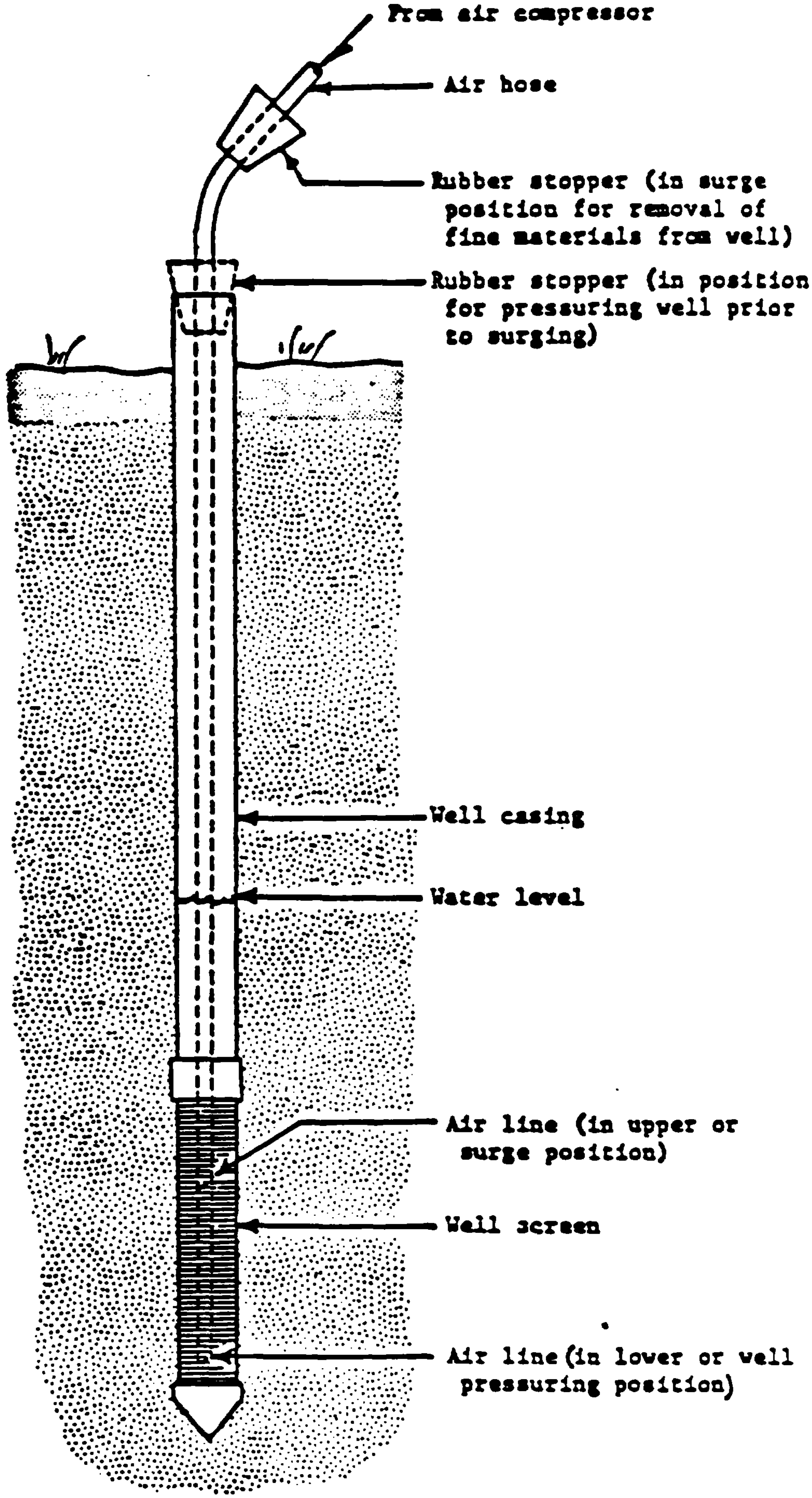


Figure 2. - Diagram of a small-diameter well showing air-surging equipment installation.

After you have performed the above-described development, you can pump the well by air-lift method if you have a reasonable amount of submergence (50 percent or more).

Occasionally, water-resources district or project personnel want to use plastic pipe for casing small-diameter wells. The use of plastic pipe, perforated or screened, poses considerable problems in development. The foremost of these problems is the susceptibility of the plastic pipe to breakage when shocking it with a violent surge of pressure. Even if there are only a few feet of water above the air-line outlet, you will get a momentary pressure shock of whatever pressure you turn into the well through the air line. In other words, if you instantaneously hit the well with 100 psi, that is the pressure you exert against the pipe. Most plastic pipes will not stand up to this kind of pressure and will burst.

Some degree of success in development of plastic screens and pipes can be accomplished by using proper care. Instead of an instantaneous release of air at 100 psi, as in the case with metal pipes and screens, it is necessary to introduce the air at a slowly increasing rate up to a maximum of 50 psi. As in the previous example, when the water quits flowing over the top of the pipe, shut the air supply off and allow the formation water to reenter the well, repeating the whole procedure as long as necessary to clean the water and develop the well.

The most important thing to remember in well development is the fact that any success you may earn is dependent upon the amount of fines that you are able to remove from the formation. These fines can only be removed by somehow bringing them into the well and pumping or bailing them to the surface. In the case of air-lift development, these fines are carried into the well when the head or pressure of the water in the formation is greater than the head inside the casing. This head difference occurs only when you remove water from inside the casing. Any outward pumping or blasting of air out through the screen or perforations will help in unplugging the face of the screen, but does little to improve the permeability of the formation surrounding the screen.

Mechanical Surging

Another type of surging action that is often very effective in the development of a well is the one using a surge plunger (usually referred to as a surge block). The two types of surge plungers commonly used are the (A) solid, and (B) valve type. Figure 3 illustrates both types of surge plungers. Either type of surge plunger should be constructed so that there is no more than 1/4-inch clearance between the surge leathers and the casing.

Since the valve-type plunger produces a lighter surging action and a lighter surging action is beneficial in developing tight formations, it is better to start with this type of plunger. Before starting any type of mechanical surging, you should make sure that you have some water entering the screen. If the screen is absolutely plugged, surging will not work as a development tool. Prior to surging, a bailer can be used to remove some or all of the water from the pipe, and then you can tell if the screen is plugged by observing the reentry rate of the water.

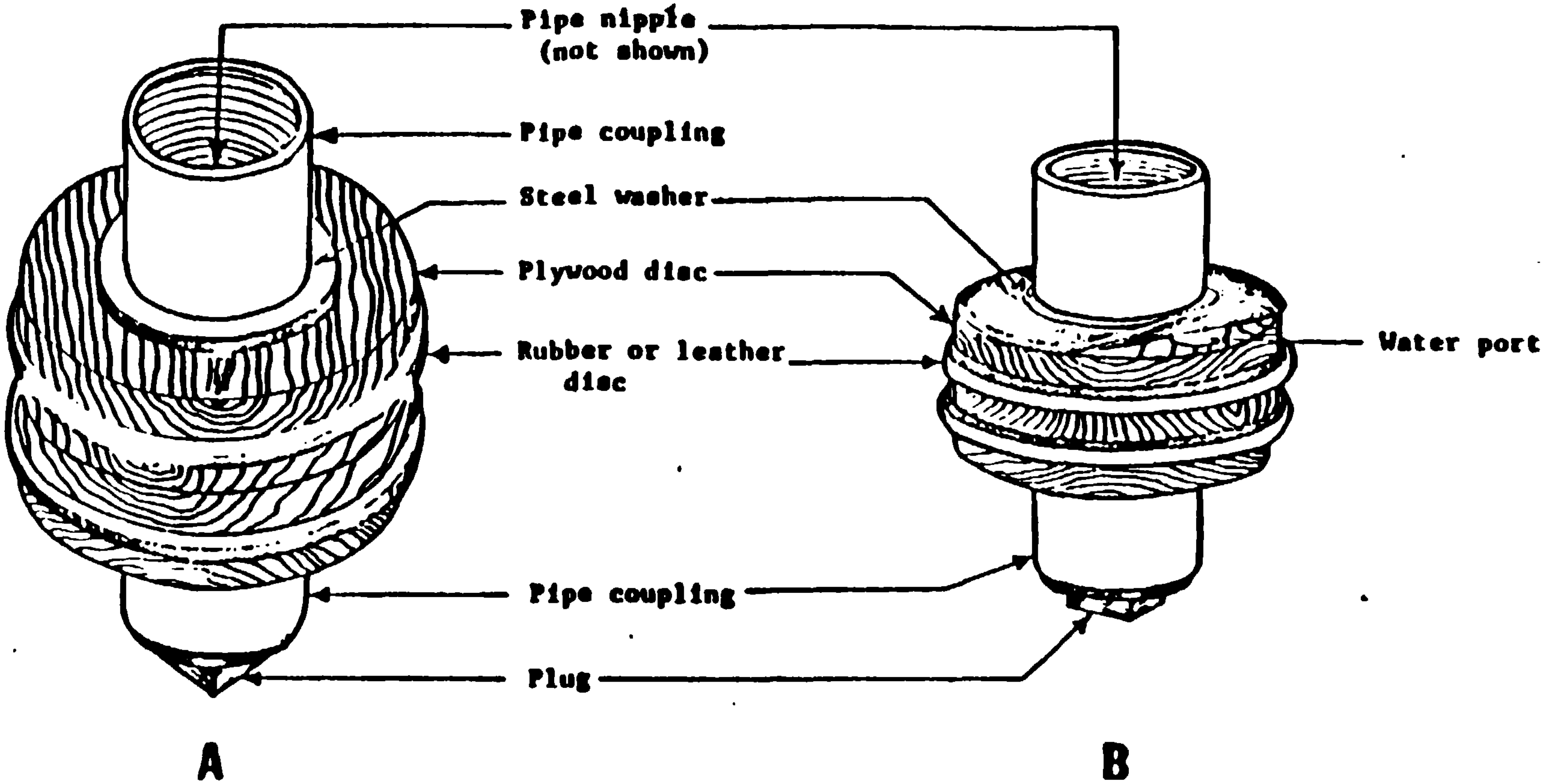


Figure 3. - Diagram showing a typical solid-type surge plunger (A) and a typical valve-type surge plunger (B).

The following is a typical procedure for using the surge plunger, described in a step-by-step fashion.

Lower the surge plunger into the well, on suitable pipe or drill stem, until you are about 10-20 feet below the surface of the water. With the lowering pipe fastened to either the sandline or catline, start a smooth up-and-down motion of about 3 or 4 feet. As the plunger moves down, water will move by and through the plunger while, at the same time, applying a small outward or flushing action against the screen. As the plunger is reversed, the action will actually draw the water up, much as a suction pump operates. This will decrease the head inside the casing and cause fine particles and water to come into the pipe. This surging action can be carried on for minutes or hours, depending upon the amount of fine materials you are able to pull into the pipe. To prevent the possibility of sand locking the plunger in the pipe or hav to lift too heavy a column of fines, it is necessary to periodically remove the surge plunger and bail the sand and other fines from the well.

Occasionally, when surging with the valve-type surge plunger, you will actually pump water over the top of the pipe. This will do no harm as long as there is not so much sand in the water that you might sand-lock the plunger in the well.

Enough weight must be attached to the surge plunger to make it drop readily on the downstroke. A common mistake in using the surge plunger is not having it weighted sufficiently. A heavy string of pipe can provide the needed weight.

Although surge plungers are ordinarily used in larger diameter wells, I have used them in wells as small as 2 inches with good succes

High-Velocity Jetting

High-velocity jetting is an excellent tool for cleaning screens or perforations and usually is adequate to break up or destroy any filter cake on the hole wall. The following discussion on procedures for high-velocity jetting is from Edward E. Johnson, Inc., "Ground Water and Wells."

Jetting with water at high velocity is generally the most effective method of well development. This method has the following prime advantages:

1. The energy is concentrated over a small area with correspondingly great effectiveness.
2. Every part of the screen can be covered selectively and, if well screen openings are closely spaced and correctly shaped to direct the jet stream out into the surrounding formation material, complete development is achieved.
3. It is relatively simple to apply and is not likely to cause trouble from over-application.

A relatively simple jetting tool, together with a high-pressure pump and the necessary hose and piping, are the principal items of equipment needed. The forceful action of high-velocity jets working out through the screen openings agitates and rearranges the sand and gravel particles of the formation surrounding the screen. The wall or filter cake deposited on the borehole in the conventional rotary method of drilling is effectively broken up and dispersed so that the drilling mud can be easily pumped out.

The procedure consists of operating a horizontal water jet inside the well in such a way that the high-velocity streams of water shoot out through the screen openings as shown in figure 4. By slowly rotating the jetting tool and gradually raising or lowering it, the entire surface of the screen gets the vigorous action of the jet. A swivel connection between the hose and pipe is a convenience. Also, a clamp with a handle for turning the pipe should be provided.

Fine sand, silt, and clay are washed out of the water-bearing formation. The turbulence created by the jet brings these fine materials back into the well through screen openings above and below the point of operation.

Where possible, it is highly desirable to pump the well lightly at the same time that the high-velocity jet is working. This is not always practical but should be done when the size of the well, the available equipment, and the position of the static water level in the well permit.

In operation, the jetting procedure adds water to the well at a rate depending on the size of the nozzles and the pump pressure. If more water is pumped from the well than the volume of water added by the jetting, the water level in the well will be kept below static level, and some water will move from the formation through the well screen while the work proceeds. The movement of water into the well helps remove some of the material loosened by the jetting.

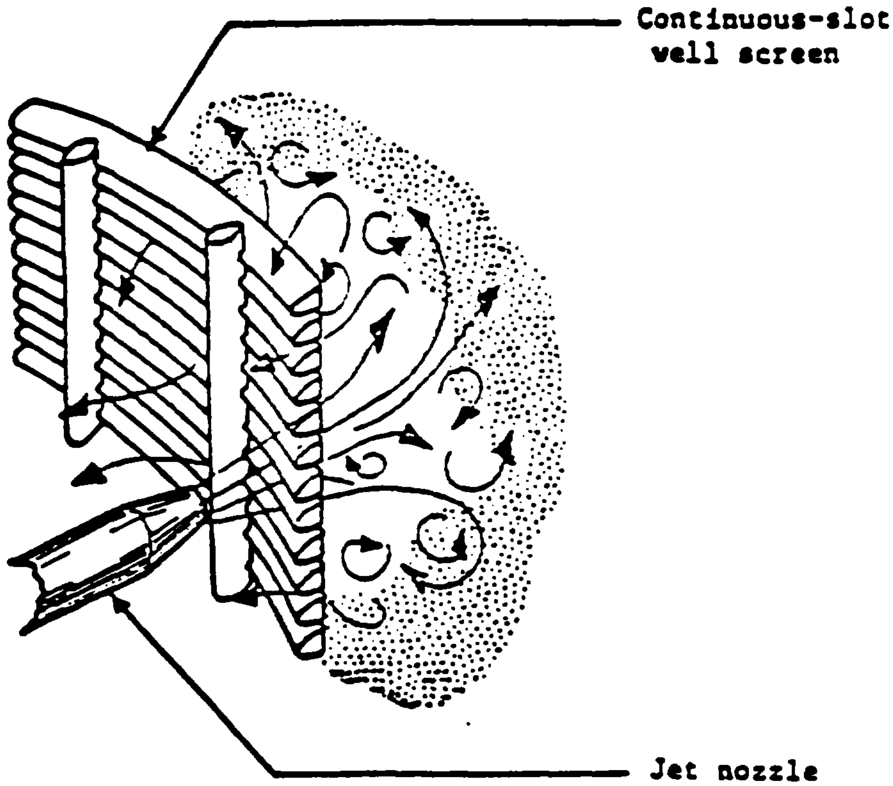


Figure 4. - Figure showing the effects of high-velocity jetting used for well development through openings in a continuous-slot well screen.

The equipment required for jet development includes a jetting tool with two or more nozzles, high-pressure pump, high-pressure hose and connections, string of pipe, and a water tank or other water supply. A pump or air lift that will pump water from the well while the jetting is under way should be added when conditions permit its use.

Figure 5 shows a simple type of jetting tool with four nozzles. If two nozzles are used, they should be spaced 180 degrees apart, three nozzles should be spaced 120 degrees apart, and four nozzles should be spaced at 90 degrees, thus hydraulically balancing the unit during operation. Best results are obtained if the nozzles are designed for maximum efficiency, but straight-drilled holes in a plug or cap will be acceptably effective.

The lowest velocity at which a jet may be considered effective is about 100 feet per second (fps). Much better results can be expected when the pressure is increased to produce velocities of 150 to 300 fps. Velocities greater than this will not be of much more benefit in development and may cause abrasion damage to the screen.

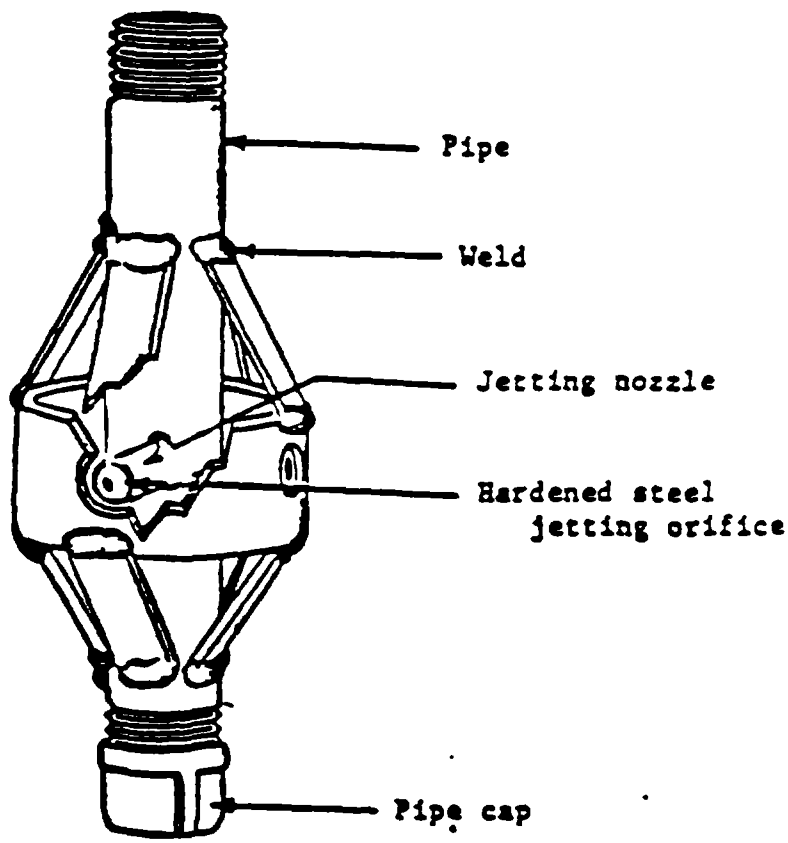


Figure 3. - Diagram showing a simple type, four nozzle jetting tool.

Table 1 provides data for nozzles and jets of several sizes at differing operating pressures.

Table 1

Approximate Jet Velocity and Discharge Per Nozzle

Size of Nozzle Orifice Inches	Pressure 100 psi		Pressure 150 psi		Pressure 200 psi		Pressure 250 psi	
	Velocity fps	Discharge gpm	Velocity fps	Discharge gpm	Velocity fps	Discharge gpm	Velocity fps	Discharge gpm
3/16	120	9	150	12	170	13	190	15
1/4	120	16	150	21	170	23	190	26
3/8	120	36	150	46	170	53	190	59
1/2	120	66	150	82	170	93	190	[illegible]

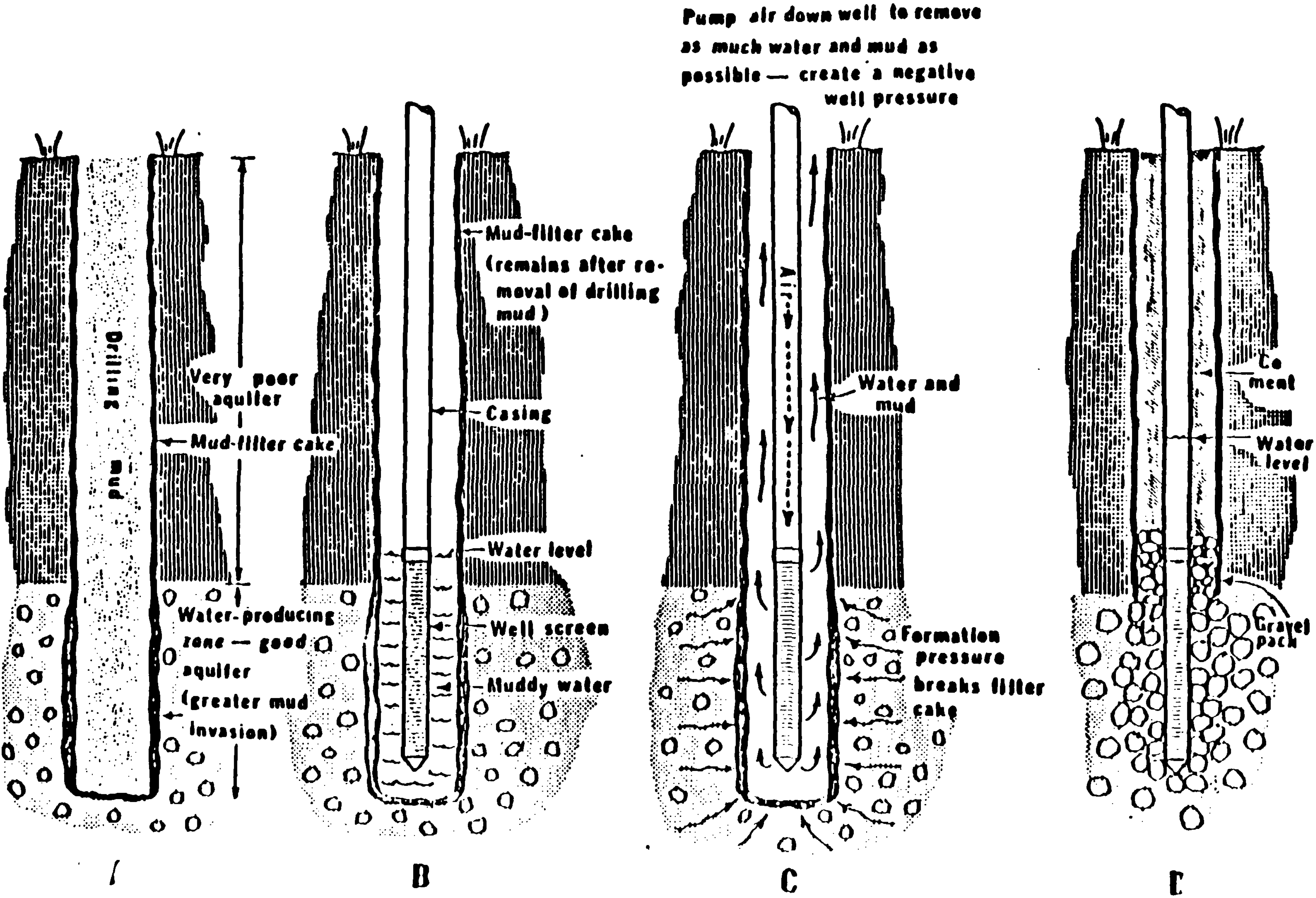
High velocity jetting is an excellent method of development in wells that can be completed without casing. In rock or consolidated material the only material that has to be dislodged and removed from the well is the filter-cake membrane or rind left on the hole wall as a result of drilling. The high-velocity jet will do an excellent job of flushing this filter cake off of the hole wall. After the filter cake is disintegrated, it will remain in fluid suspension for a short period of time and can be pumped or bailed from the well.

Backwashing

Backwashing, or forcing water back through the well screen or perforations, is one of the easiest but also least effective methods of well development. The backwash method is often adequate to dislodge fine particles from the immediate area of the screen, but it accomplishes little or nothing toward the actual development of the formation that the screen is set in.

In order to fully understand the reasons for usual failure in this type of development attempt, let us look at the cause and effect of the problem. In the case of mud-rotary drilling, we are forcing a mud-cake buildup on the wall of the hole as we drill. As drilling progresses, the drilling fluid tries to permeate into any available permeable zone encountered. As the porous zones, at or near the face of the drill hole, are plugged by fine particles in the drill fluid, a mud cake or filter cake builds up on the wall of the borehole, figure 6A. This rubbery lining of silt, clay, and colloids is formed by a filtration effect when pressure of the drilling fluid squeezes some of the water out of the fluid. The filter cake plasters the wall of the hole and holds loose particles or crumbly materials in place. It helps protect the wall from being washed or eroded by the upward stream of drilling fluid. It acts to seal the wall and reduces the loss of fluid into permeable formations.

If we install a screened or perforated casing in a mud-rotary drilled hole, as shown in figure 6B, we will have the mud-filled hole plus the filter cake on the wall to worry about in the development procedure. After installation of the casing, the first and, unfortunately, often the only step toward development of the well is to hook a water-supply hose to the



Pump air down well to remove as much water and mud as possible — create a negative well pressure
Drilling mud
Very poor aquifer
Mud-filter cake
Water-producing zone — good aquifer (greater mud invasion)
Mud-filter cake (remains after removal of drilling mud)
Casing
Water level
Well screen
Muddy water
Air
Water and mud
Formation pressure breaks filter cake
Cement
Water level
Gravel pack
B
C

top of the casing and backwash with clean water until all of the drilling fluid has been removed from the hole. This is certainly a necessary step, but it usually accomplishes little or nothing toward the actual development of any water-bearing formation. The nonsuccess of this procedure toward development is logical when we consider the fact that we are still applying a positive or outward pressure on the filter cake, and no amount of pump pressure is going to destroy it.

What we have to do then, in the case of developing a well in a mud-rotary drilled hole, is destroy or break down this filter cake. This can usually only be done by lowering the water level in the hole to a point where the hydrostatic head of the formation fluid is greater than that in the hole as shown ideally in figure 6C. The filter cake can hold loose particles in place because it is sticky and plastic, but it cannot prevent even a small outside pressure from collapsing the hole. Resistance to collapse results from the outward hydrostatic pressure of the drilling fluid. The filter cake should be thought of only as a flexible lining or membrane, somewhat like a rubber balloon placed in the hole and filled with drilling fluid.

The water level can be lowered, in this case, and development completed by air pumping the well as previously described. As the fluid level is lowered inside the well below the static level of the formation water, the unconsolidated formation will collapse against the casing and screen (figure 6D), and continued pumping and resting the well will usually result in removing the fines around the screen and permit you to pump them to the surface.

When a hole is drilled by the auger method, you often get a plastering effect on the hole wall caused by fines or viscous muds dropping off of the auger flights and adhering to, or even being embedded in the side wall. This plastering, or rind on the wall, acts very much the same as a filter cake, and any successful development has to be carried out as though you were dealing with a mud-rotary drilled hole.

In the case of auger-drilled holes that collapse through the water-bearing zones upon withdrawal of the augers, backwashing can be a successful means for total development. This is due to the fact that the formation materials are in or very near contact with the screen. Any fine materials that plug or adhere to the screen as you push through the collapsed material can be readily flushed away from the screen by backwashing. This is usually adequate development for an observation well installed in an auger hole where the walls of the hole have collapsed. One precautionary note about backwashing through a screen: Occasionally, you may observe a situation where the pump water pressure increases as you are attempting to flush a screen by the backwash method. This occurs only when you are connected directly to the casing with your pump hose, and it is a result of pumping entrained air through the screen into the formation surrounding the screen. This air can plug the formation to a point where it may require as much as 200-psi pump pressure to move even a small amount of water through the screen. If the screen has been cleared of clay, silt, and other fine particles, the plugging effect caused by air bubbles will eventually correct itself by dissolving or natural release of the air.

Summary

Any method that we use to drill a well is going to cause some problems that will make it difficult to install a screened observation well that can be absolutely responsive to the water-bearing formation. Various development methods, however, can usually restore the materials immediately adjacent to the screen to a reasonable degree of response. The most important thing to remember is that the fine materials have to be removed from the water-bearing formation and, although these fines can be moved around and redistributed by various development techniques, they can only be removed from the formation by a technique that lowers the water level inside the casing to a point where the higher water head on the outside forces the fines into the screen where they can be pumped out.

Occasionally, observation wells can be installed in auger holes, containing clean sand and gravel, that require no development. You can readily determine whether or not a screen is open and responsive to the formation by conducting a quick slug test. This is done by first measuring the static water level in the well. After the static water level has been determined, a few gallons of water are rapidly introduced into the pipe and the rate of decline of the water level is measured. If the water-level decline is rapid (reaches static within a few minutes), no further development is usually needed.

Air development is probably the single most effective means of development. Although our trucks are not equipped with air compresso[illegible] they are often available to the district or project offices that you will be working with. Because of the time involved in tying up a drill rig and the relative ease of installing air-development tools (hose or lightweight pipe), the project personnel should be encourage[illegible] to perform this development work after you have demonstrated the meth[illegible]. It will cost a lot less for them to do the development without tying up a drill rig for relatively long periods of time.

References

Johnson, Edward E., Inc., 1966, Developing and Completing Water Wells in Ground Water and Wells, 1st ed.: Edward E. Johnson, Inc., St Paul, Minnesota, p. 295-312.

CHAPTER 17
REFERENCES

References Supporting Chapter 1

Environmental Response Team, 1980. Field Monitoring and Analysis of Hazardous Materials. EPA Training Manual, Course #165.4, Cincinnati, Ohio.

Environmental Protection Agency, 1973. Handbook for Monitoring Industrial Wastewater. U.S. EPA Technology Transfer.

Environmental Protection Agency, 1974. Methods for Chemical Analysis of Water and Wastewater. U.S. EPA Technology Transfer.

Environmental Protection Agency, 1972. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. U.S. EPA-600/4-79-019.

Environmental Protection Agency, 1977. Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities. EPA/530/SW - 611.

Huibregtse, K.R., and Moser, J.H., 1976. Handbook for Sampling and Sample Preservation of Water and Wastewater. U.S. EPA-600/4-76-049.

Municipal Environmental Research Laboratory, 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. Environmental Protection Agency, Cincinnati, Ohio. EPA-600/280-018.

National Enforcement Investigations Center, 1980. Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Sites by Contractors. EPA Office of Enforcement, Denver, Colorado.

Olson, D.M., Berg, E.L., Christensen, R., Otto, H., Ciancia, J., Bryant, G., Lair, M.D., Birch, M., Keffer, W., Dahl, T., and Wehner, T., 1977. Compliance Sampling Manual. Enforcement Division, Office of Water Enforcement, Compliance Branch.

Weber, C.I., 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. U.S. EPA-670/4-73-001.

References Supporting Chapter 4

A Condensed Guide to Chemical Hazards (CHRIS), Vol. I and II, 1978. Department of Transportation, U.S. Coast Guard, Washington, D.C.

American National Standard, Commodity Specification for Air, 1973. American National Standards Institute, ANSI 286.1-1973, New York.

American National Standards Practices for Respiratory Protection, 1969. American National Standard Institute, ANSI, Z88.2-1969, New York.

Dangerous Properties of Industrial Chemicals (Irving Sax), 5th ed. 1979. Van Nostrand Reinhold, New York.

Dictionary of Scientific and Technical Terms, 2nd ed. 1978. McGraw-Hill, New York.

DOT Specification Cylinders-Shipping Containers (40 CFR 100-199). U.S. Department of Transportation, Washington, D.C.

Effects of Exposure to Toxic Gases - First Aid and Medical Treatment. 2nd ed. 1979. Matheson, Lyndhurst, N.J.

Fire Protection Guide on Hazardous Materials (NFPA) 7th ed. 1978. National Fire Protection Assn, Boston.

Hazard Materials Regulations of the Department of Transportation. (Tariff No. BOE-6000-A). 1980. Bureau of Explosives, Washington, D.C.

OSHA Safety and Health Standards (29 CFR 1910). Revised 1979. U.S. Department of Labor, Washington, D.C.

Toxic and Hazardous Industrial Chemicals Safety Manual. 1979. The International Technical Information Institute, Tokyo.

References Supporting Chapter 6

Environmenta• Response Team, 1980. Field Monitoring and Analysis of Hazardous Materials. EPA Training Manual, Course #165.4, Cincinnati, Ohio.

Environmental Protection Agency, 1973. Handbook for Monitoring Industrial Wastewater. U.S. EPA Technology Transfer.

Environmental Protection Agency, 1974. Methods for Chemical Analysis of Water and Wastewater. U.S. EPA Technology Transfer.

Environmental Protection Agency, 1972. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. PA-600/4-79-019.

Environmental Protection Agency, 1977. Procedures Manual for Ground-water Monitoring at Solid Waste Disposal Facilities. EPA/530/SW-611.

Huibregtse, K.R., and Moser, J.H., 1976. Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA-600/4-76-049.

Johnson Division, UOP Inc., 1975. Groundwater and Wells. Pub. Johnson Division UOP, Inc., St. Paul, Minnesota.

Municipal Environmental Research Laboratory, 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. Environmental Protection Agency, Cincinnati, Ohio. EPA-600/280-018.

National Enforcement Investigations Center, 1984. Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Sites by Contractors. EPA Office of Enforcement, Denver, Colorado.

Olson, D.M., Berg, E.L., Christensen, R., Otto, H., Ciancia, J., Bryant, G., Lair, M.D., Birch, M., Keffer, W., Dahl, T., and Wehner, T., 1977. Compliance Sampling Manual. Enforcement Division, Office of Water Enforcement, Compliance Branch.

Weber, C.I., 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. EPA-670/4-73-001.

References Supporting Chapters 7, 8, 9 and 10

Environmental Research Center, University of Nevada, Las Vegas. Preparation of Soil Sampling Protocol: Techniques and Strategies. *Benjamin J. Mason.* 1983.

Municipal Environmental Research Laboratory, 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. Environmental Protection Agency, Cincinnati, Ohio. EPA-600/280-018.

National Enforcement Investigations Center, 1984. Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Sites by Contractors. EPA Office of Enforcement, Denver, Colorado.

Provost, Lloyd P. Statistical Methods in Environmental Sampling. Radian Corporation, Austin, Texas. 1984.

Agencies of the United States Government, 1980. National Handbook of Recommended Methods for Water-DAta Aquisition. Chapter 2, Ground Water

Barcelona, Michael J., James P. Gibb, John A. Helfrich, and Edward E. Garske, 1985. Practical Guide for Ground-Water Sampling. ISWS Contract Report 374.

Barcelona, Michael J., James P. Gibb, and Robin A. Miller, 1983. A Guide to the Selection of Materials for Monitoring Well Construction and Ground-water Sampling. ISDWS Contract Report 327.

Scalf, Marion R., et. al., 1981. Manual of Ground-water Quality Sampling Procedures. National Water Well Assocation.

United States Environmental Protection Agency, 1981. Technical Methods for Investigating Sites Containing Hazardous Substances. Technical Monograph No. 16, Water Sampling Methods for Field Investigations (Draft).